

Corrosion

Official Publication
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



FEBRUARY, 1974

YOU CAN *Specify* MINIMUM MAINTENANCE COSTS WITH *Amercoat* PROTECTIVE COATINGS

ONLY AMERCOAT PROVIDES YOU WITH

The most complete line
of corrosion resistant
coatings available anywhere

Field service backed by
an organization SPECIALIZING
in corrosion control

The service life of your equipment—the efficiency of your production schedules — the ultimate value of your investment and maintenance dollars — all are vitally dependent on the continuing performance of the protective coatings specified in your plant. Thus, success or failure of your coatings can mean the difference between tremendous losses or substantial savings.

To assure coating performance that provides long-lasting, low-cost protection, two steps are absolute essentials, right from the start. You need the right coating for each specific exposure, and it must be applied properly if it is to yield maximum benefit.

AMERCOAT ELIMINATES THE GUESSWORK—MINIMIZES MAINTENANCE COSTS

First of all, AMERCOAT provides the right coating for the particular problem. From the complete AMERCOAT line, it is possible to provide specific coatings for specific exposures to achieve specified protective performance.

In addition, you receive the added value of AMERCOAT's conscientious service follow-through backed by an organization SPECIALIZING in industrial corrosion control. With the assistance and on-the-spot advice of a trained representative, you get the best possible application through proper attention to surface preparation and correct coating techniques.

Investigate AMERCOAT now. It's your surest way to effective, long-term corrosion control. An experienced representative is near you to serve you. For complete details write today.

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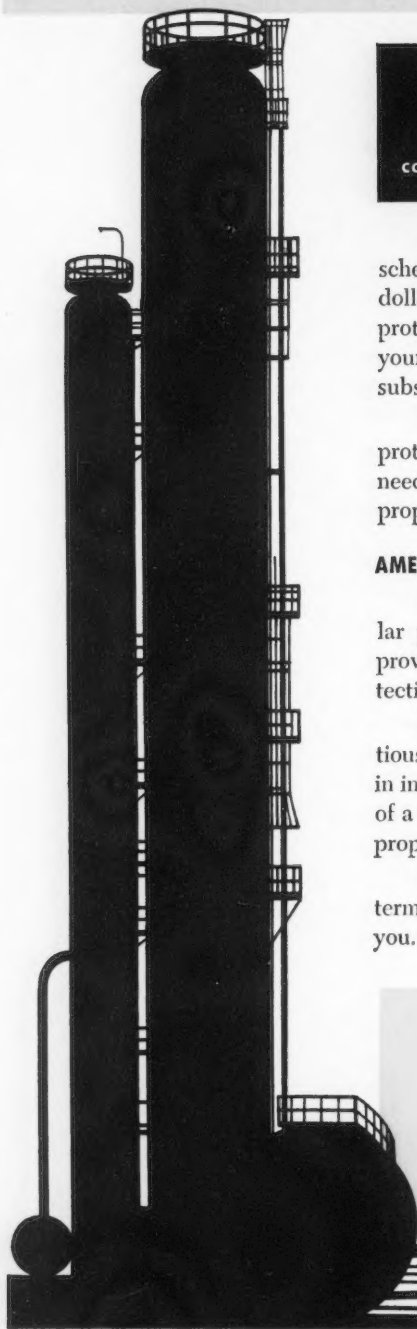
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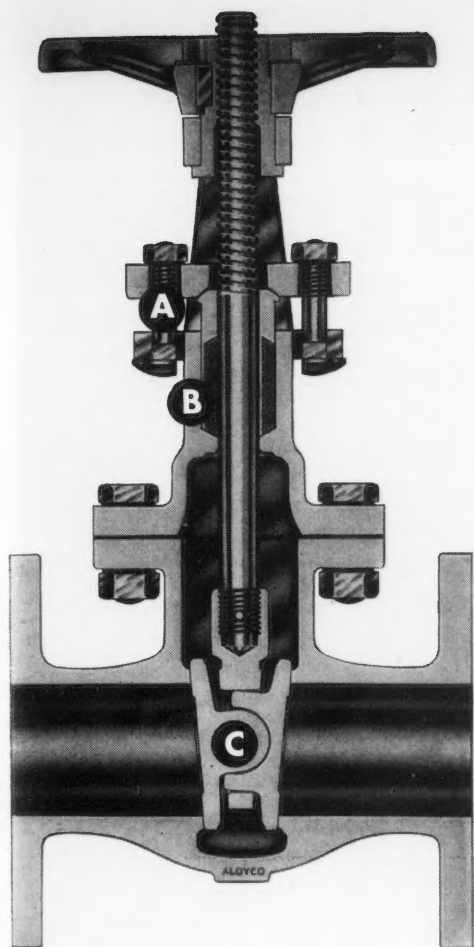
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CORROSION



ALOYCO 111-A GATE VALVE

Advanced features of these valves increase their corrosion-resistance

- Double disk ball-and-socket type wedges are free to rotate and are non-fouling in any position to assure pressure tightness on both seats.
- Stuffing boxes may be repacked with Teflon or conventional packing material even when valve is under pressure and wide open.
- Rocker type gland plates and guided gland followers prevent marring of the stems when repacking.
- Handwheels keyed to yoke-bushings for easy disassembly.
- All parts are of corrosion-resistant alloy except yoke-bushings, nuts and handwheels. Available from ½" to 12". Alloys regularly stocked are Aloyco 20, 18-8S and 18-8SMo.

This Aloyco 20 valve cuts maintenance costs in corrosive service

- Prevent valve corrosion from eating into your production and profits!

How? Look to Aloyco, the world's largest specialists in the manufacture of corrosion-resistant valves, for the valve design and alloy that will give lasting, maintenance-free performance.

Mechanically, this Aloyco Gate Valve 111-A is evidence of the careful attention given every detail of construction that marks Aloyco's complete line. To determine the best materials for each specific application, our engineers will be glad to pre-test various alloys under your actual line conditions and base their recommendations on actual service data.

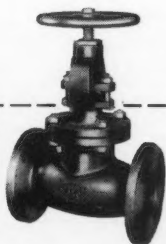
If you have a problem of valve maintenance or replacement because of corrosion, write to Aloyco's Corrosion Engineering Service about your own valve needs. Or call your nearest Aloyco distributor.

- A. Rocker type gland plates and guided gland followers.
- B. Teflon packing for stuffing box (optional).
- C. Double disk, ball-and-socket type wedges.

ALOYCO 20

This alloy was specifically developed to provide corrosion-resistance against a wide range of sulphuric acid concentrations and temperatures.

Since its inception, Aloyco 20 has also proved highly effective in handling varied concentrations of sludge acid, caustic soda, fatty acids, acetic acid, phosphoric acid, chlorinated hydrocarbons, and many other process solutions.



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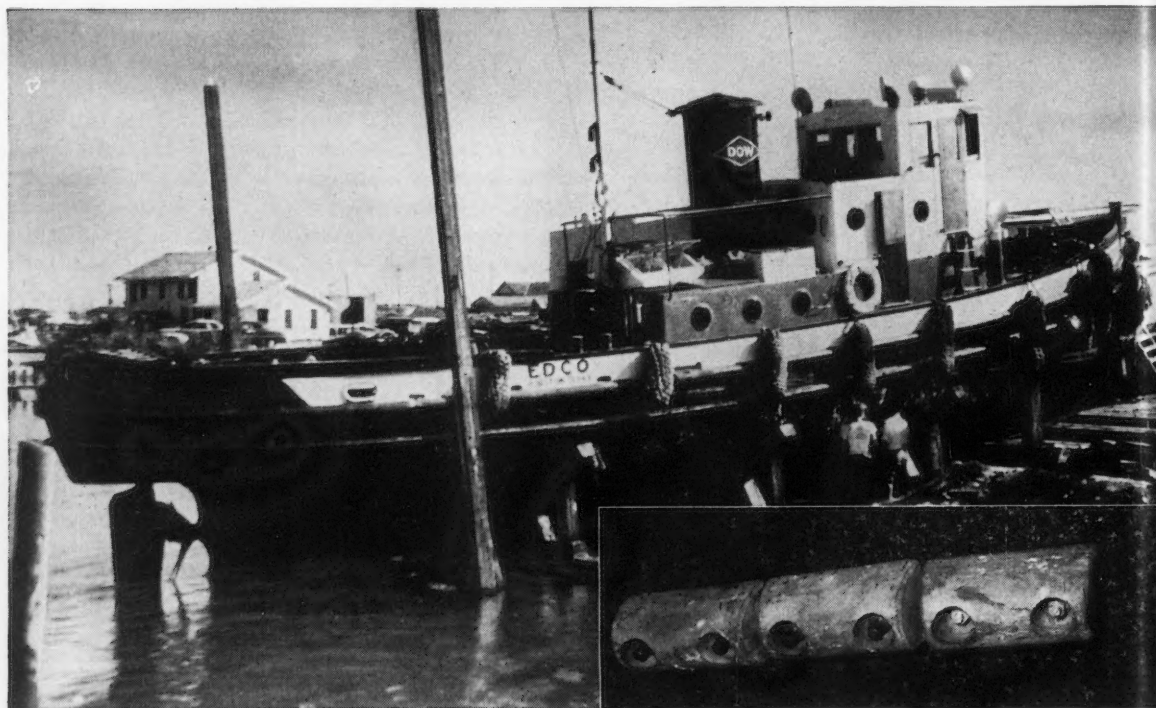
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Longer Lasting
ALOYCO VALVES
1st in Corrosive Service



MAGNESIUM ANODES PROTECT SMALL CRAFT FROM CORROSION

Extensive tests conducted on tugs, LCM's, and fishing craft demonstrate the effectiveness of anodic installations



Anodes, made of magnesium, have proved to be the most efficient, the most effective (and the most practical!) protection against the deteriorating, corrosive action of sea water on the hulls of ships.

This has been demonstrated on sea-going vessels of all types and sizes. Tests have been conducted on ships as large as The Dow Chemical Company's 13,000-ton "Marine Chemist" and on smaller craft, such as the kind of tugs, barges, and scows you find in most harbors.

In every case the results have shown that magnesium anodes stop corrosive action and provide positive protection for underwater surfaces. Magnesium anodes save

operators money, too, by reducing the need for descaling, expensive paint coatings, sandblasting, and other methods of fighting corrosion.

Magnesium anodes are relatively simple to install. And so far as maintenance is concerned, they require only occasional replacement. Furthermore, their effect on speed or handling of the vessel is negligible.

Why not look into magnesium anodes for your ships? You will find it to be a small investment that will repay you many times over. For a free, informative, illustrated booklet on magnesium anodes, write today to THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

you can depend on **DOW MAGNESIUM ANODES**



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Corrosion



THIS MONTH'S COVER—A workman of the Long Island Painting & Decorating Co. is applying a 1/8-inch coating of Thiokol-bearing "DEL" Synthetic Rubber Caulking Compound, made by David E. Long Corporation, New York. Sea water from Jamaica Bay ranging from 32 to 76 degrees F. is pumped into the condenser. The coating is expected to last months longer than the one previously used.



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NEWS REPORTS FOR CORROSION

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• News of meetings of corrosion interest of whatever origin are welcomed and will be carried when space permits.

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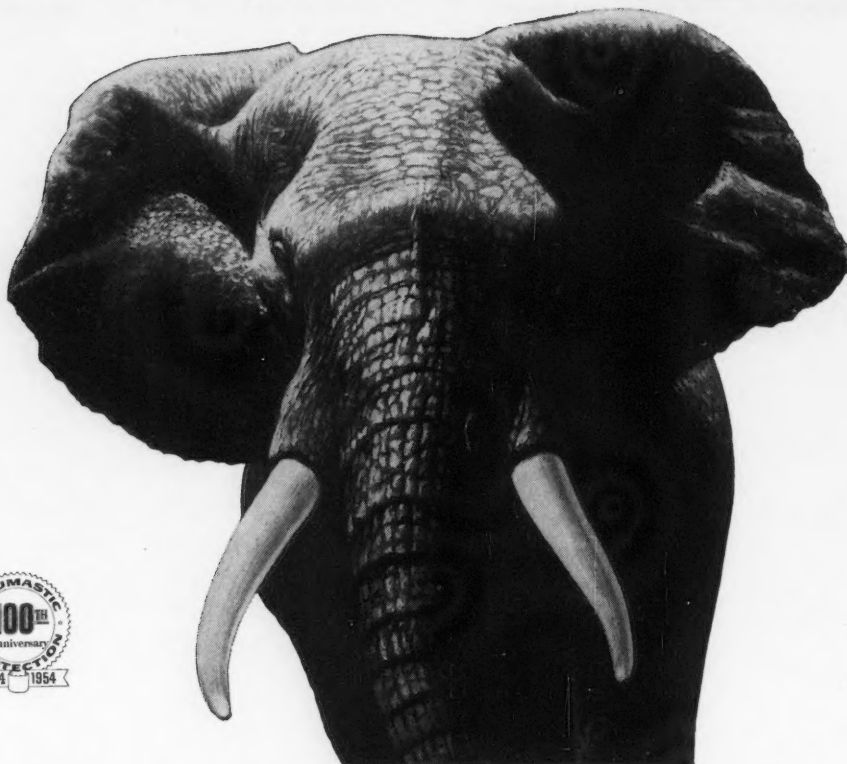
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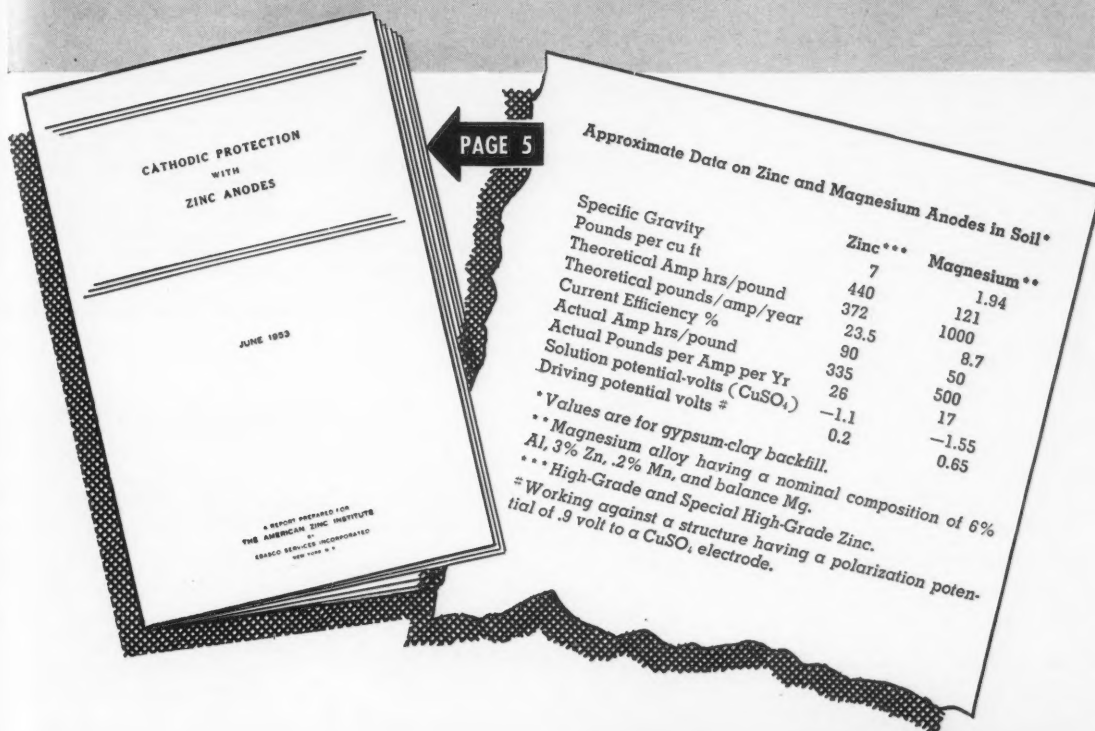
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TP-8A Corrosion by Gulf Coast Cooling Waters. Charles P. Dillon, chairman, Carbide and Carbon Chemicals Co., Texas City, Texas. W. B. Brooks, vice-chairman, Dow Chemical Company, Freeport, Texas.

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TP-13 ANNUAL LOSSES DUE TO CORROSION

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See Page 48 of this issue for a schedule of the meetings of NACE Technical Committees to be held at Kansas City during the Tenth Annual Conference and Exhibition March 15-19.

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Straight from the Kettle on PIPE PROTECTION

By Boyd Mayes

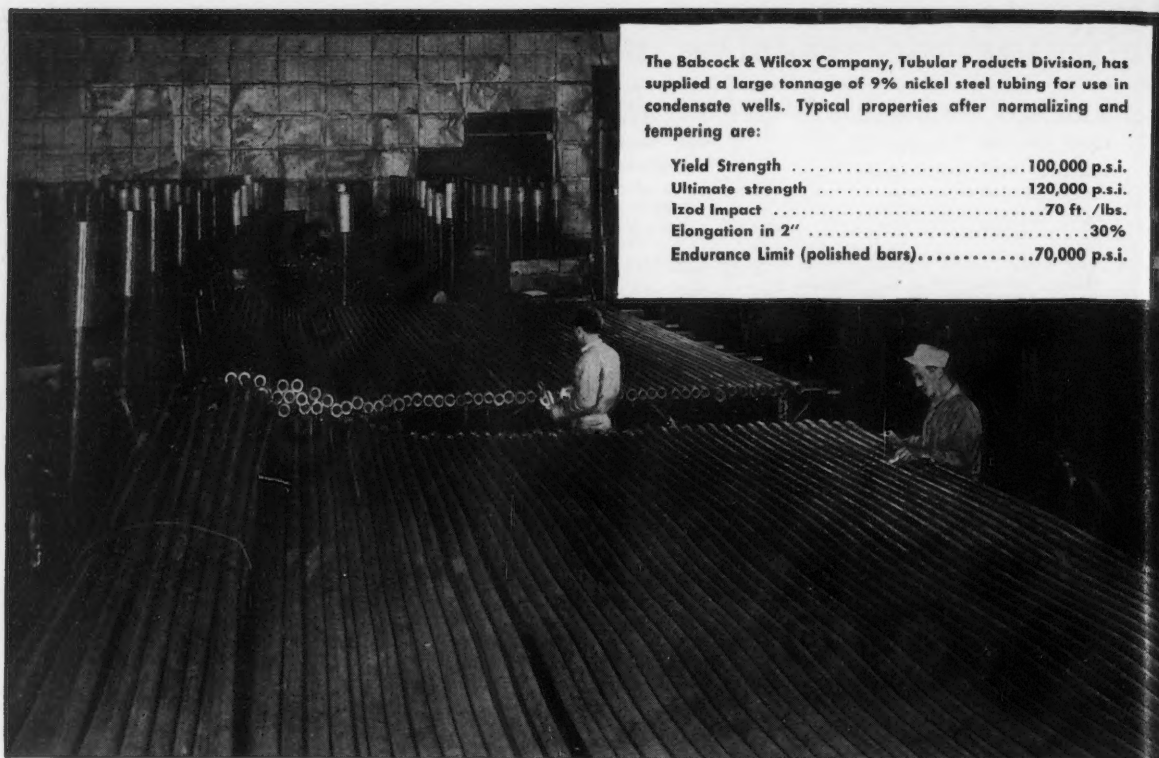
• Used to be an Old timer named Josh who sat in a chair all day on the board floor in front of the general store in our home town. He'd tilt the chair back, close his eyes, and just rest all day. Josh saw more and rested more than anybody we ever knew. Somehow, just sitting still made all the folks think he was wise. He did pass out some pretty smart thoughts, at that. One time I asked him why he was always in such a good mood and he said: "Anybody who does his job well and likes what he is doing is happy. Take me for example. I just sit all day and rest . . . an' I enjoy it—but some folks can't even enjoy sittin' still."

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Technical data on B&W Nicloy-9, as well as similar information on Nicloy-5 and -3½, is given in B&W Technical Bulletin 18, copies of which are available on request to The B&W Company, Tubular Products Division, Beaver Falls, Pa.

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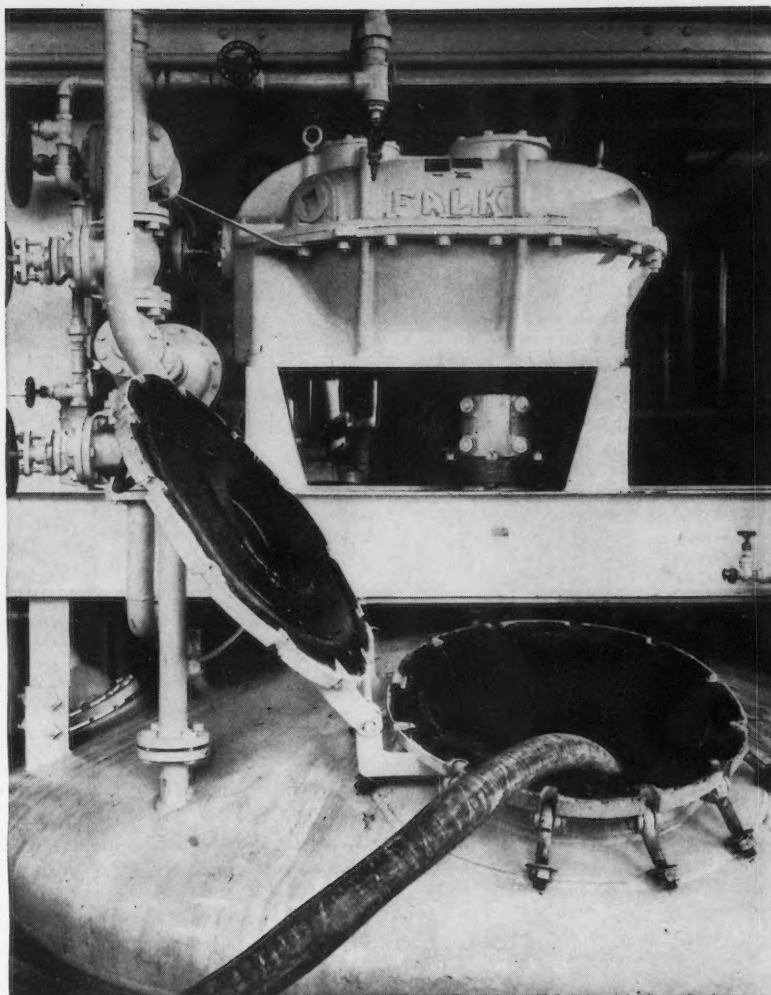


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


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THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

- (a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.
- (b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.
- (c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.
- (d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.
- (e) To promote standardization of terminology, techniques, equipment and design in corrosion control.
- (f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.
- (g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.
- (h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.



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1954 Annual Conference and Exhibition

By HARRY K. PHIPPS*

General Convention Chairman

THE NACE is returning to Kansas City, the location of its second convention and first exhibition, to hold its Tenth Annual Conference and Exhibition, March 15-19, 1954. As your General Convention Chairman, I am looking forward to one of the most successful Annual Conventions of the Association. My task has been largely one of coordinating the plans for the three main assignments, local arrangements under Charles C. Keane, the technical program under Frank L. Whitney, Jr., and the exhibition under O. E. Murrey. All three of these men have been diligently at work during the past year in making and carrying out their respective parts of this meeting. Mr. Keane and his assistants, mostly from his organization, have completed plans for the Friendship Hour, the Annual Banquet, Entertainment for Ladies, Registration, and numerous other details that need to be arranged to make the Convention a success. Mr. Whitney, with his Co-chairman, H. L. Bilhartz, has prepared a program of speakers on technical subjects on a wide variety of problems in the control and mitigation of corrosion, the main objective of the Association. Papers and discussions will be presented on 14 main groups beside three educational lectures. With the exception of one of these groups, all will be at the Municipal Auditorium where exhibits will be held. This group, a series of eight small round-table meetings, will be held simultaneously in a near-by hotel. The Exhibition will be held in the Exhibit Hall of the Auditorium where 140 booths will be occupied by approximately 95 exhibitors, several of whom have exhibited at every NACE Convention since the first Exhibition in 1946.

One of the most interesting and valuable features of this Convention will be the series of Technical Committee Meetings that have been scheduled beginning

with Sunday, March 14 and extending through the convention period. Monday, March 15 will be given over almost exclusively to these meetings, a time schedule of which will be found elsewhere in this issue of CORROSION. These technical committee meetings have come to be one of the most valuable parts of our Annual Convention for it is here that corrosion problems and committee procedure are discussed and plans formed for committee work during the coming year. An effort has been made to coordinate these meetings with the technical symposia to avoid conflicts between committee meetings and symposia dealing with the same subjects.

An Advance Program for this Convention has been mailed to all members of the Association and a final and complete program will be available when registration opens at the Auditorium at noon, Sunday, March 14.

For companies or organizations operating physical plant subject to corrosion, this will be a great opportunity to send engineers and technicians to a group of technical committee meetings, papers and discussions all of which deal with corrosion problems. Also, a great opportunity will be afforded these men to visit the exhibits of some 95 exhibitors who will be displaying materials and equipment used to prevent or control corrosion. Valuable information can be obtained in a few hours by visiting these exhibits and talking with those in charge, that could not be obtained otherwise except through the expenditure of large amounts of time and money. As one who has learned from experience what corrosion losses are costing industry in this country, I urge all interested in reducing corrosion losses to plan to attend this meeting or send representatives. Members and non-members who register will be welcome at all meetings.

* Socony-Vacuum Oil Co., Inc., Central Pipe Lines Div., Wichita, Kansas.

Thirty Years' Experience In Testing Aluminum Paint Performance *

By ROBERT I. WRAY

THE PAINT INDUSTRY, which at one time considered the manufacture of paint as a closely guarded art, has accepted wholeheartedly the chemist and the laboratory. The technical laboratory today is an indispensable part of any paint manufacturing establishment and great strides have been made in the improvement of paint performance through the use of test methods developed by the chemist.

Since 1922, investigators working in Aluminum Research laboratories have been testing different kinds of paint to evaluate their serviceability for a large variety of applications. In addition to extensive tests of aluminum paint, the tests have included paints for Alcoa's plant maintenance and coatings for protecting or decorating aluminum in its various forms. The importance of conducting tests that could be evaluated for different types of service was fully recognized. Hence, a number of different kinds of exposure tests were necessary. Where practical, a control coating with known characteristics was included for purposes of comparison.

Panel Preparations

The first step in an exposure test is the preparation of the specimens so that undesired variations in the panels will be eliminated. For example, the edges and corners of panels for immersion tests are carefully rounded by filing in order to minimize edge effects. Panels are then cleaned or chemically treated in order to provide a good surface for painting. The treatment employed will depend upon the metal as well as the type of test. Flat steel panels are usually solvent cleaned, while panels of aluminum alloys are customarily given a treatment with a dilute aqueous solution of phosphoric acid combined with a grease solvent. When different surface treatments are to be compared, the same paint coating is used on all panels.

In applying the paint to the panels, uniformity of film thickness is of utmost importance if accurate comparisons are to be made. Film thickness may either be measured directly or calculated from the weight of paint applied. On large panels, it is more convenient to apply equal weights of paint estimated to give the required dry film thickness. Consequently, this method is employed in Aluminum Research Laboratories' tests where large panels are used. On small specimens, film thickness is determined by means of a bench micrometer or film thickness gage.

ROBERT I. WRAY, Chief of the Paint Finishes Division, Aluminum Research Laboratories, New Kensington, Pa. He holds an AB from DePauw University, 1917; and BSChE from Purdue University, 1922. A veteran of World War I, he was employed by Aluminum Research Laboratories as a research chemist on graduation and has been there since. In 1926 he received a Professional Degree of ChE from Purdue. He is author of a number of articles on aluminum paint and painting of aluminum and is a member of ACS, AIChE and the Federation of Paint and Varnish Clubs.



Abstract

Descriptions and illustrations are given of the results achieved with coatings of various kinds, including different formulations of aluminum paint on steel and aluminum bases at the Aluminum Laboratories' several testing stations. Advantages of proper surface preparation and application techniques are demonstrated by improved service life in both long and short time tests. Tests show relative merits of various primers and of aluminum paint as an intermediate coat. Methods of testing employed at Aluminum Laboratories are described and illustrated.

If the panels are coated by spraying, care is taken to obtain as uniform spray application as possible. In certain cases, automatic spraying is used to assure uniform film thickness. It is more difficult to obtain uniformity in brush application, but with care reasonably uniform results can be secured. The importance of good brush application is illustrated strikingly by the two steel panels shown in Figure 1. After four years' exposure the panel on the left indicates the value of uniform application, while the panel on the right shows the type of failure that may result from poor brushing technique.

Types of Tests Employed at Aluminum Research Laboratories

Among the various types of exposure tests conducted at Aluminum Research Laboratories, atmospheric exposure on the roof of the Laboratories is of prime importance for evaluating a large variety of coatings. These tests are conducted on steel, galvanized steel, aluminum alloys, wood, concrete and various miscellaneous surfaces. In most cases the metal panels are mounted at an angle of 45 degrees to the vertical, facing south. Flat metal panels are mounted in porcelain insulators to avoid contact with the racks. Wood panels are mounted vertically using screws. Figure 2 shows a general view of the roof exposure tests. Some of these panels have been under

* A paper presented before Atlanta Section, Southern Zone Paint and Varnish Production Club, October, 1952, and at a meeting of Southeastern Region, National Association of Corrosion Engineers, Chattanooga, Tenn., May 7, 1953. Most of the work described herein was done at Aluminum Research Laboratories, New Kensington, Pa.



Figure 1—Effect of good (left) and poor (right) brush application of aluminum paint. (After 4 years' exposure.)



Figure 2—Roof exposure test racks, New Kensington, Pa.

test for 15 to 20 years. A record of weather conditions during tests is maintained.

Supplementing the New Kensington roof exposure tests, seacoast atmospheric tests are conducted at a station located at Point Judith, Rhode Island. Here the panels are mounted in special frames attached to the 45-degree racks which are located a few hundred feet from the surf. The coast is rocky at this point and the panels are continually bathed in an atmosphere of salt mist. A general view of this station is shown in Figure 3. As might be expected, paint failure is more rapid at this station than at New Kensington, Pa.

An accelerated exposure test which has been found to be very effective for evaluating paint coatings on metal specimens is illustrated in Figure 4. In this test the specimens are alternately immersed in a 3.5 percent sodium chloride solution and then exposed to sunshine, rain and air. The equipment is located outdoors on the laboratory grounds in New Kensington. It comprises a series of four large aluminum tanks 6 x 10 feet and 18 inches deep filled with simulated sea water. A metal frame is suspended above each tank from a movable beam which is actuated by a motor and train of gears. The motor is connected in circuit with an electric timing device which can be set to raise or lower the framework automatically in any desired cycle. Panels are mounted on the frame so that they are exposed to an angle of 45 degrees to the vertical, facing south. The cycle employed in the tests consists of five minutes in the salt water and 25 minutes in air. The results obtained are comparable to those obtained in tidewater exposure. A limited use has also been made of actual tidewater tests at Miami.

Another type of test consists of complete immersion in river water. For this work, use is made of a large concrete basin located along the banks of the



Figure 3—Point Judith, R. I., atmospheric exposure station.

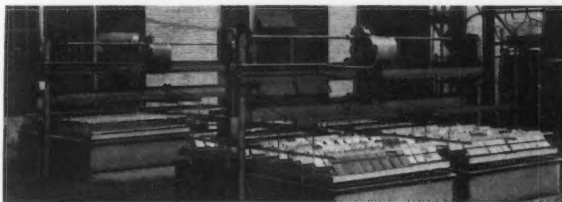


Figure 4—Alternate immersion test equipment.

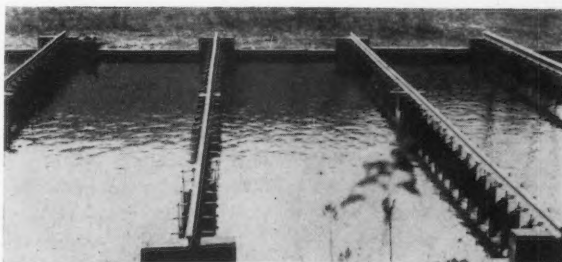


Figure 5—River water test basin, New Kensington, Pa.

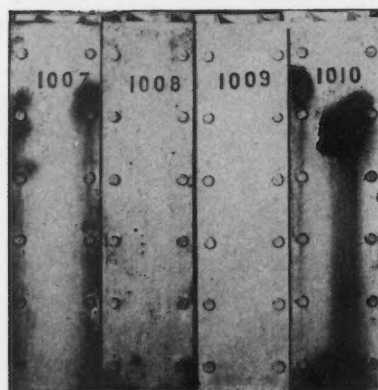


Figure 6—Effect of surface preparation of structural steel on serviceability of paint coatings.

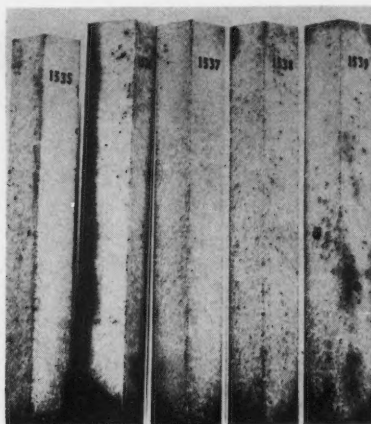


Figure 7—Comparison of various types of primers for structural steel.

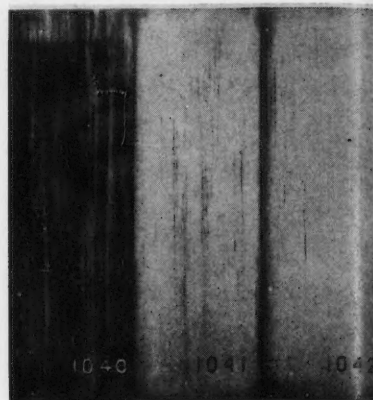


Figure 8—Effect of pigment concentration on durability of aluminum paint.

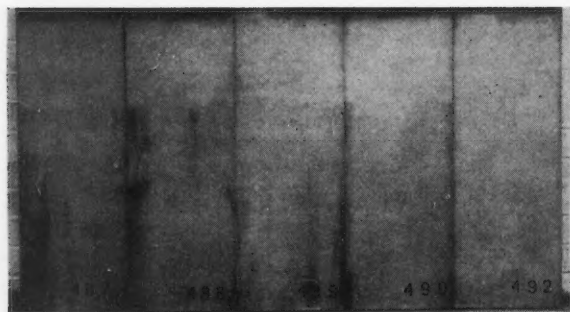


Figure 9—Comparison of aluminum paints made with pigments having different leafing values (highest leafing on right).

Allegheny River at New Kensington. The basin is filled with river water by means of a pump which intermittently pours water into the basin. An overflow at one end returns the excess water to the river. There is thus a limited amount of water flow through the basin. The panels under test are suspended in the water on hooks attached to rails placed across the basin. A photograph of this basin is shown in Figure 5. During the 14 years it has been in use, valuable information concerning paints suitable for underwater use on dams, barges, etc. has been obtained from this test.

In addition to the tests described above, a number of other tests are also conducted on certain coatings. These include exposure to air of 100 percent relative humidity at 125 degrees F, or to salt spray or in a Weather-O-Meter. Measurements of abrasion resistance, flexibility, heat and chemical resistance may also yield valuable information.

Roof Exposures

For roof exposure, the first step is the selection of the type of specimen to be employed. For example, more reliable information concerning the performance of painting systems for structural steel can be obtained if the paints are applied to structural steel shapes. On the other hand, the relative merits of a group of paints of similar character may be deter-

mined by using flat panels. In the case of paints for aluminum alloys, it is usually desirable to include panels of various alloys, both wrought and cast.

The surface preparation of structural steel for painting has been the subject of a number of investigations in recent years. Because of the importance of aluminum paint on bridges, oil tanks, and other structures, Aluminum Research Laboratories has also investigated this problem with interesting results. Several riveted steel box girder sections were obtained and the surface of the sections was treated in various ways as follows:

Panel 1007—Wire scratch brushed followed by treatment with proprietary phosphoric acid-chromate solution

Panel 1008—None

Panel 1009—Light sandblasting

Panel 1010—Wire scratch brushed

The sections were then given one coat of a zinc chromate primer followed by two coats of aluminum paint. After three years' exposure the mill scale on the surface of the solvent-cleaned section had completely loosened the paint, causing it to peel. Some paint peeling had occurred on the section that had been wire brushed, and failure had also started on the wire brushed and inhibited section. Practically no failure was noted on the sandblasted section. The sections were then refinished with a touch-up coat of primer, where required, and given two coats of aluminum paint. Section 1008, which had received no surface preparation initially, was completely primed while the sandblasted section 1009 required the use of no primer. The appearance of these sections after four years' additional exposure is shown in Figure 6. It will be noted that the sandblasted section is still in excellent condition. Section 1008 from which the mill scale had weathered was now in much better condition than the wire brushed section. The use of chemical inhibitor following scratch brushing appears to offer some advantage.

A simpler type of structural steel specimen is illustrated by the panels shown in Figure 7. These structural steel angles received the same surface treat-

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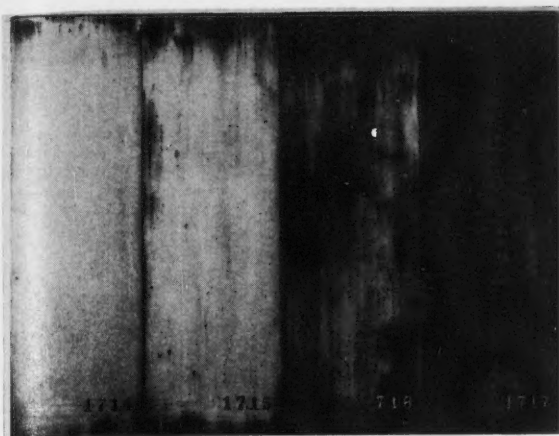


Figure 10—Effect of addition of mica to aluminum paint on its ultimate durability.

ments and were primed with different primers followed by two coats and aluminum paint. Angles 1535, 1537 and 1538 were primed with long oil primers, whereas the other two angles were primed with alkyd base paints. The advantage of long oil primers, after three years' exposure, is clearly evident.

The effect of pigment concentration on the durability of aluminum paint is shown in Figure 8. Flat steel panels were used for this test. Two coats of aluminum paint made with different concentrations of aluminum pigment were applied and the panels were exposed for $5\frac{1}{2}$ years. The panel on the left was finished with paint containing 1.5 pounds of standard paste per gallon of vehicle, while the paint on the other two panels was made with 2 and 2.5 pounds of paste per gallon, respectively. The panel with the low pigment concentration shows considerable rust streaking, whereas very little failure will be noted on the other two panels.

Many of the valuable properties of aluminum paint coatings depend upon satisfactory leafing of the pigment. Shown in Figure 9 is a group of steel panels which illustrates the value of good leafing of aluminum pigments. Two coats of aluminum paint were applied to each panel. The leafing values of the pigments (ASTM Method D480-48) were, ranging from left to right, 42, 47, 52, 57 and 64 percent, respectively. After three years little failure was noted in paints made with the better leafing pigments, whereas moderate rusting had occurred with poor leafing pigments. The use of adulterants such as mica in aluminum paint also decreases durability. The aluminum pigment used on panels 1714 to 1717 inclusive, shown in Figure 10, contained 0, 25, 50 and 75 percent mica, respectively; two coats of paint were applied to each panel. After $2\frac{3}{4}$ years' exposure very little failure will be noted on the panel finished with paint containing no mica, whereas progressive failure occurred with increasing mica content. In other tests it has been found that the presence of even 10 percent mica decreased the durability of the paint.

The type of vehicle used in making the aluminum paint has an important bearing on the performance

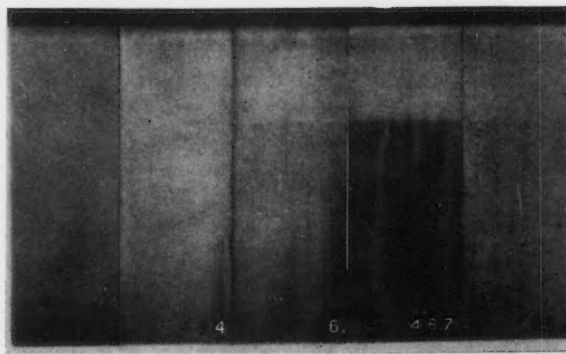


Figure 11—Aluminum paints made with different types of vehicles.

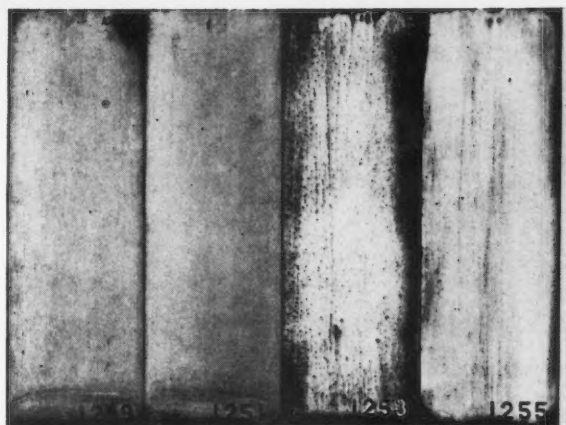


Figure 12—Comparison of aluminum (left) with white (right) top coats on steel panels—10 years' exposure.

of the coating. The steel panels shown in Figure 11 were given two and three coats of aluminum paint made with different vehicles. After 7 years' exposure on the roof, the superior durability of aluminum paint made with alkyd (panel 463) and pure phenolic (panel 464) resin varnishes was apparent. The vehicle used on panel 466 was a modified phenolic resin varnish, on panel 467 an ester gum varnish and on panel 468 a coumarone resin varnish.

Aluminum paint has long been an accepted finish coating for use in the painting of oil storage tanks. From time to time various special chalking type white paints have been suggested as satisfactory substitutes. In order to determine the relative durability of aluminum paint and some of these white paints, a series of steel panels was prepared with an inhibitive primer followed by two coats of aluminum paint or two coats of white paint. The topcoats were applied by spraying. After 10 years' exposure the aluminum painted panels showed very little failure, whereas the white finished panels were covered with rust pits. Failure of the white paints started after about 5 years. The appearance of the panels after 10 years' exposure is shown in Figure 12.

Seacoast Atmospheric Tests

Most of the paint tests at the seacoast atmospheric station have been made on aluminum alloy panels,

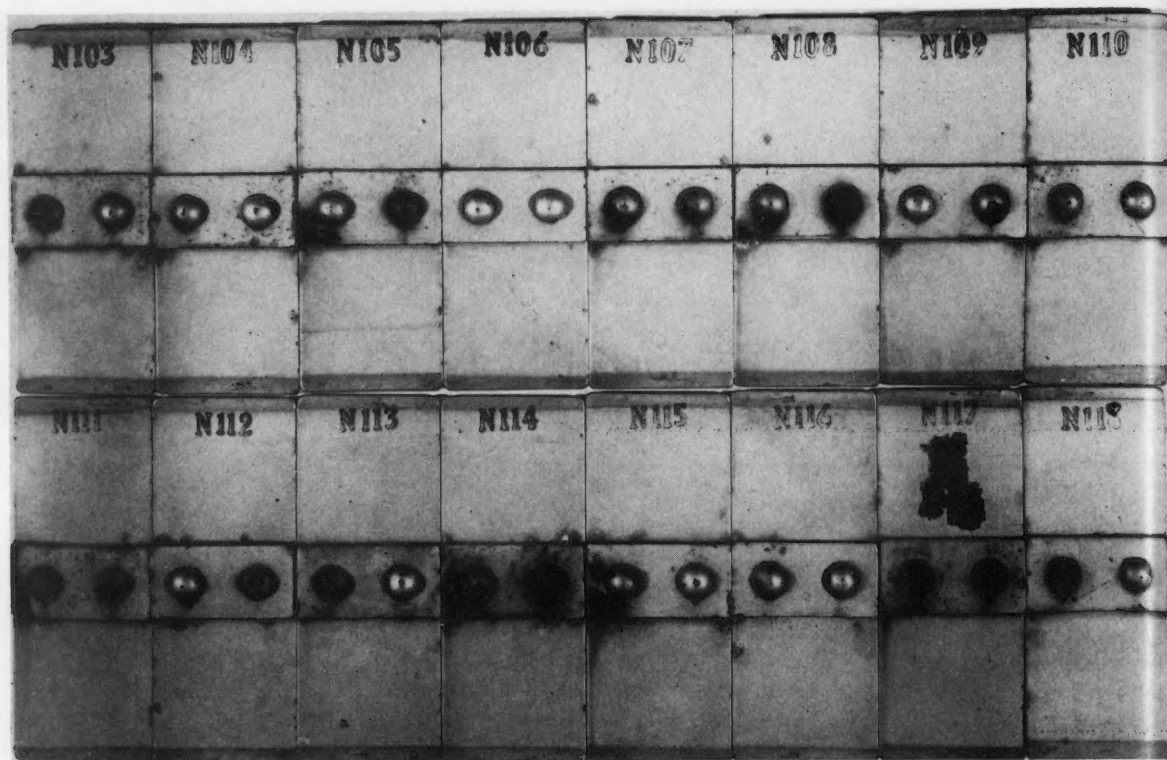


Figure 13—Comparison of aluminum sections primed with different kinds of primers after three years at Point Judith, R. I.

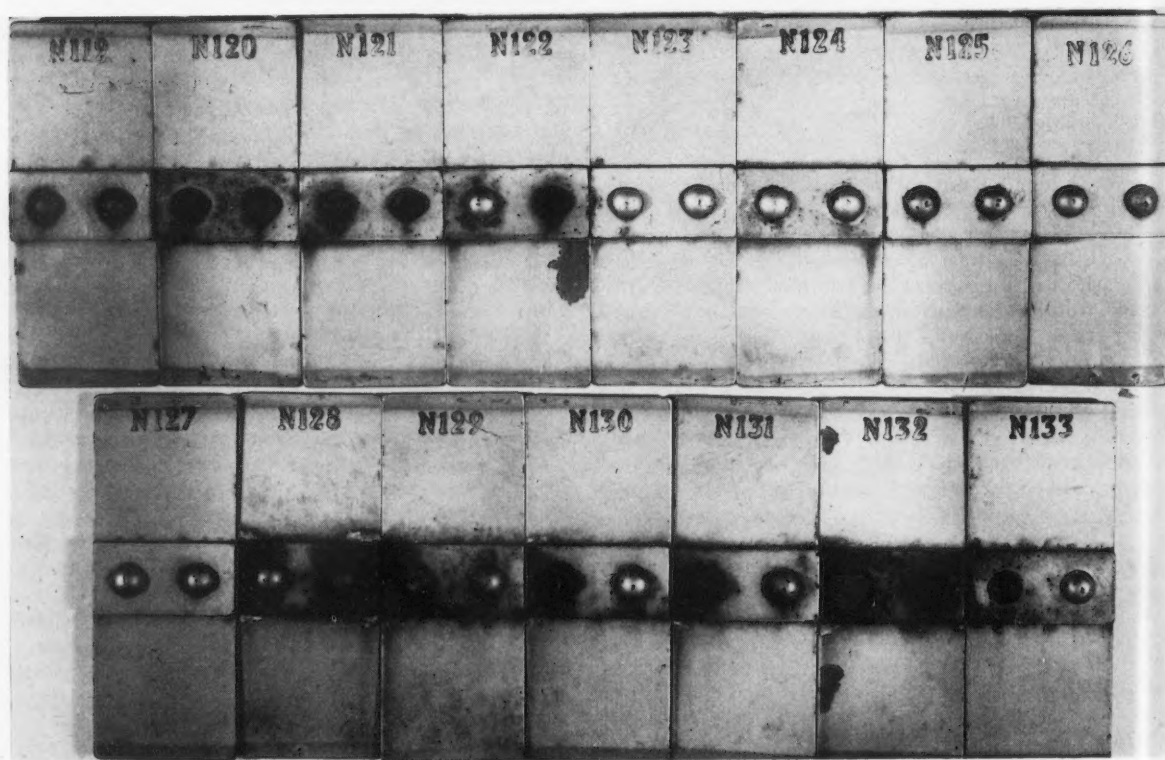


Figure 14—Comparison of aluminum sections primed with different kinds of primers after three years at Point Judith, R. I.

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although some steel panels have been included. Paint protection of aluminum in marine environments is called for more often than is the case at inland locations. Because of the better inherent corrosion resistance of aluminum alloys, paints applied to aluminum usually show a longer useful life than when applied to steel.

Figures 13 and 14 show a number of painted specimens of aluminum alloy plates to which narrow steel strips were riveted with hot driven steel rivets. This particular investigation covered a large series of metal primers, too extensive to discuss in detail here. Similar panels had been exposed in the outdoor alternate immersion tank and in tidewater at Miami. The sections were primed before assembly; the rivets were touched up with the corresponding primers and a coat of aluminum paint made with a phenolic resin varnish was applied after assembly. This test had the added advantage of observing the effect of the different primers in the dissimilar metal joint.

The results obtained after 3 years' exposure at Point Judith are of interest. It was found that primers made with alkyd resin vehicles showed better performance than those made with phenolic resin vehicles or vehicles containing combinations of these two resins. For example, Maritime Commission Specification Zinc Chromate Primer 52-MC-29, made with an alkyd vehicle, was superior to U. S. Navy Specification Zinc Chromate Primer 52-P-18 which contains a combination of alkyd and phenolic resins. One of the best primers was an alkyd base primer pigmented with calcium chromate. This was true for both the aluminum plate and the steel strip. Furthermore, there was little apparent corrosion in the aluminum-to-steel joints where these alkyd base primers had been used. Poorest results were obtained with a group of reclaimed zinc chromate primers which were very thin in consistency. The appearance of these panels after 3 years' exposure at Point Judith is shown in Figures 13 and 14. In general, the results obtained at Point Judith were in agreement with those obtained in the outdoor alternate immersion tests and in Miami tidewater.

Outdoor Alternate Immersion in Salt Water

The outdoor alternate immersion test in salt water is a form of accelerated exposure test. In common with all accelerated types of tests, the results must be interpreted with caution. This test has been found to be a very useful tool, however, in evaluating certain types of coatings on steel, aluminum and magnesium base alloys. It is particularly applicable to the examination of coatings designed for marine applications, or other uses where the metal may be in contact with corrosive environments.

As an example of a test of this type, several steel panels were primed with coatings thought to be suitable for marine use and finished with two coats of aluminum paint. The results of this test, after 43 weeks' exposure in the alternate immersion tank are shown in Figure 15. The first two panels on the left (C337 and C338) were primed with an aluminum pigment-zinc chromate primer conforming to U. S. Corps of Engineers Specification CE1409, formula



Figure 15—Comparison of different primers for steel after 43 weeks in outdoor alternate immersion tank.

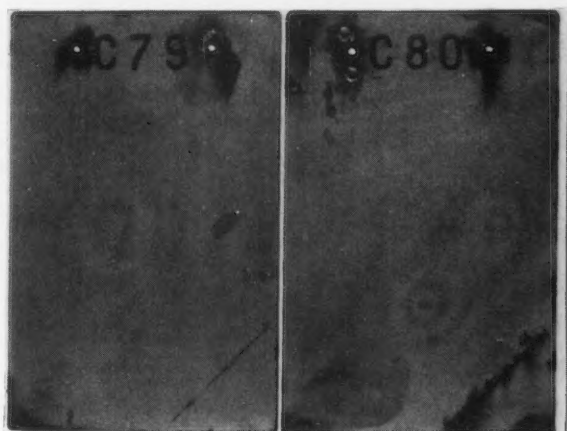


Figure 16—Value of aluminum paint as an intermediate coat after 70 weeks' exposure in outdoor alternate immersion tank.

P4, and finished with two coats of aluminum paint made with a 25-gallon phenolic resin varnish meeting Military Specification MIL-V-1174. These panels were showing severe rust blistering, particularly near edges. The center panel (C348), primed with a zinc chromate primer meeting Maritime Commission Specification 52-MC-29 and finished with two coats of the same aluminum paint, showed very little failure as did also the next panel (C349) which was given a wash coat primer followed by two coats of the same aluminum paint. The panel on the right (C350) was also given a wash coat primer but received, as topcoats, two coats of aluminum pigmented vinyl resin vehicle. This panel showed somewhat more failure than the panel having the same primer but finished with aluminum paint made with the phenolic resin varnish. Better results would doubtless have been obtained with the vinyl system if an additional coat had been applied, since the vinyl coating produced a thinner film per coat than the phenolic varnish coating. As a result of this test, the system based on the 52-MC-29 primer was recommended for a certain marine application.

The value of aluminum paint as an intermediate coat in a system involving a green top coat was demonstrated in another test the results of which

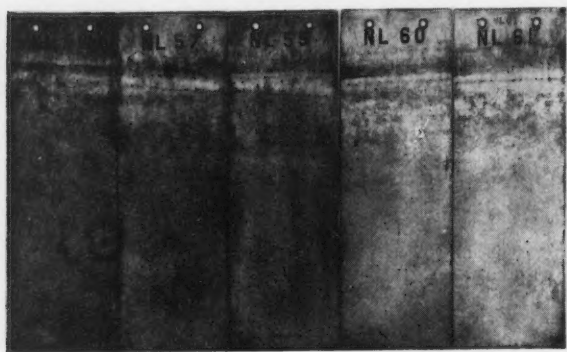


Figure 17—Various aluminum paint coatings on steel exposed for 5½ years in Allegheny river water.

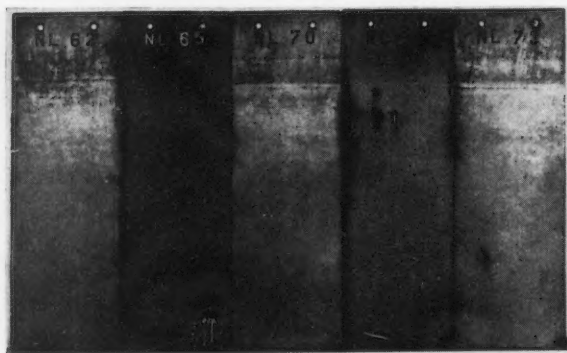


Figure 18—Comparison of aluminum paint and other paints after exposure for 5½ years in river water.

are shown in Figure 16. Two steel panels were primed with a special synthetic resin base primer. One panel (C80) was then given two coats of an alkyd resin base green enamel, while the other (C79) received one coat of aluminum paint made with an alkyd resin vehicle and one coat of green alkyd resin base enamel. A scratch was made through the coating at the lower right corner of each panel. After 70 weeks' exposure there was considerably more rust blistering on the panel finished with two coats of green enamel than on the panel with the intermediate coat of aluminum paint, especially in the scratch. As a result of this test, aluminum paint was specified as the intermediate coat on a large bridge and the method has given good service.

Complete Immersion in River Water

The painting of underwater surfaces such as steel dams, barges, etc. presents special problems which cannot be answered by the usual atmospheric exposure tests nor by any of the other tests previously described. In order to accumulate information on the performance of coatings suitable for this type of service, complete immersion tests in Allegheny River water were started about 14 years ago. The results of early tests in the test basin indicated that paints normally found suitable for protecting steel exposed to the atmosphere were unsuitable for use on submerged surfaces. It was, therefore, necessary to develop special formulations for this work.

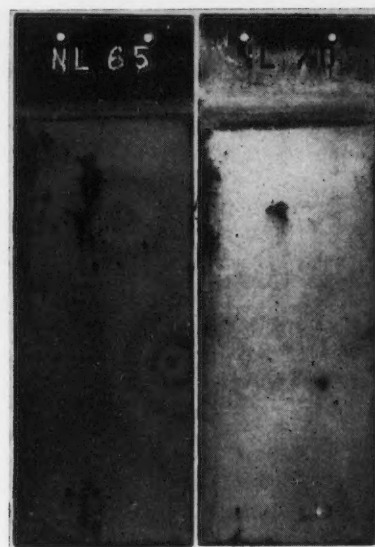


Figure 19—Comparison of top coats of gray enamel (left) and aluminum paint (right) after 10 years' complete immersion in river water.

Figure 17 shows a group of panels finished with special underwater coatings, after about 5½ years' exposure under water. The right half of each panel was given a treatment with a phosphoric acid solution, while the left half was solvent cleaned. The three panels on the left were given two coats of an aluminum pigment-zinc chromate primer after which fine sand was dusted onto the surface while still tacky. The next panel, NL60, received the same primer coatings but without the sand, while the panel on the right received a single primer coat of aluminum paint. Two top coats of aluminum paint made with a phenolic resin varnish were applied to all panels. The presence of sand in the primer on three of these panels gave them a much rougher surface which resulted in more dirt collection. However, less failure occurred on these panels than on those on which sand was not used. The use of a chemical treatment before painting on half of each panel proved beneficial, although the photographs do not show this difference clearly.

Another series of test coatings is shown in Figure 18 after about 5½ years' exposure. Panel NL62 was given three coats of aluminum paint made with a 25-gallon phenolic resin varnish; panel NL65 was primed with zinc dust paint and given two coats of a phenolic resin base gray enamel, while panel NL70 had the same zinc dust primer followed by two coats of aluminum paint. Panels NL72 and NL73 also received a zinc dust primer; panel NL72 was then finished with two coats of zinc dust paint, while panel NL73 received two coats of aluminum paint. The panels with aluminum paint topcoats were in better condition in all cases. Panels NL65 and NL70 topcoated with gray enamel and aluminum paint respectively over a zinc dust primer are also shown in Figure 19 after about 10 years' exposure. The panel with the aluminum paint topcoats showed

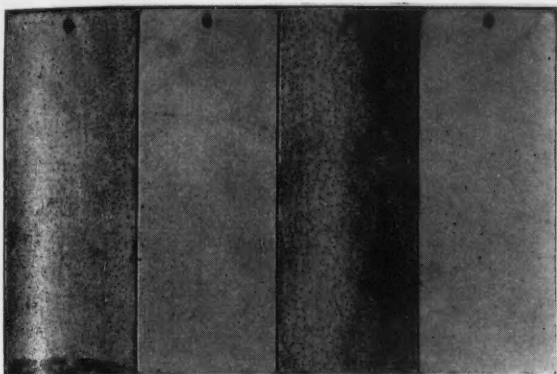


Figure 20—Panels exposed for one week in the high humidity cabinet.

fewer rust blisters than the gray finished panel, even after this long exposure.

Tests like these have been a guide to securing durable protection on submerged steel surfaces of river dams.

Humidity Tests

One form of accelerated exposure test which has received considerable attention in recent years is the high humidity test. Various organizations, such as the American Society for Testing Materials, have investigated the possibilities of this type of test for evaluating paint coatings on metal surfaces. Aluminum Research Laboratories has also used this test, to some extent, for the testing of paints. In addition to determining the ability of the finish to resist moisture penetration, the humidity test appears to give some indication of the relative adhesion of various coatings. The tests are usually conducted in air at 100 per cent relative humidity; the temperature may be varied, although in this work at Aluminum Research Laboratories the temperature has been maintained at 125 degrees F. The painted steel or aluminum panels are suspended from rods in a cabinet and examined at frequent intervals. Results are usually obtained in about one week.

Figure 20 shows four steel panels finished with a special aluminum paint after one week in the high humidity cabinet. The two panels on the left were carefully solvent cleaned before painting and received respectively one and two coats of this aluminum paint. The two panels on the right received one and two coats respectively of the same paint applied over an oily surface. Much more failure is evident on the uncleaned panels than on those which were solvent cleaned, especially where a single coat of paint was used. In both cases, however, two coats showed far less failure than a single coat.

Accelerated Weathering Test

Tests in artificial weathering machines, using ultra-violet light, are frequently thought of when reference is made to accelerated exposure testing of paint coatings. These tests have much to be said in their favor for rapid evaluation of a series of similar type paint coatings, although they also have certain disadvantages. It is not always possible to obtain exact corre-

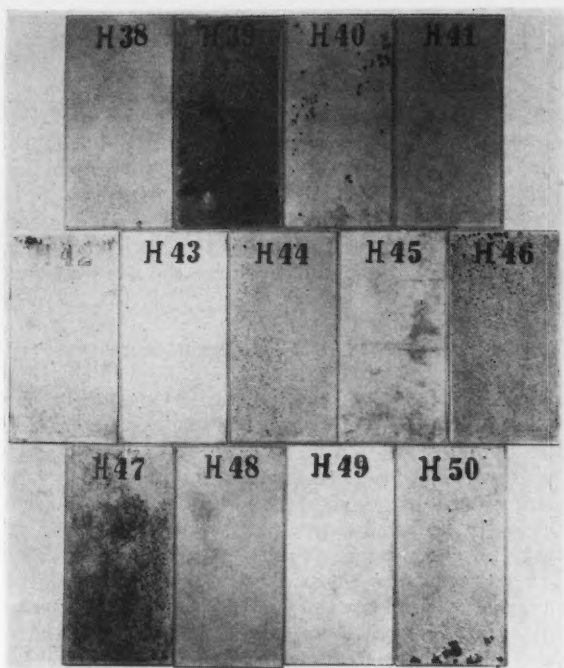


Figure 21—Various heat resistant aluminum paints after three months' atmospheric exposure.

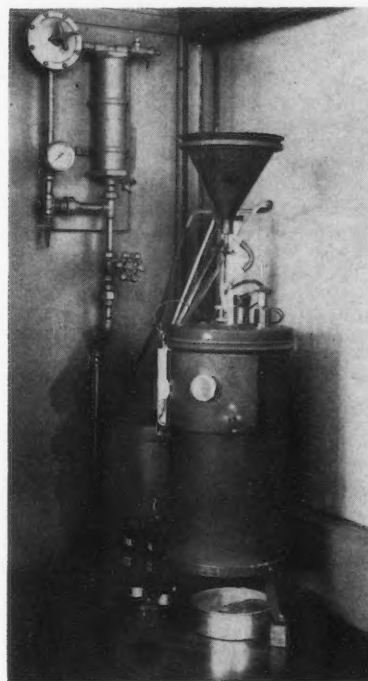


Figure 22—ASTM abrasimeter.

lation in different laboratories nor to establish a ratio of time of failure in this accelerated test and in natural weathering. Accelerated weathering tests are employed to some extent at Aluminum Research Laboratories, although other tests such as atmos-

pheric weathering and outdoor alternate immersion are more widely used.

Salt Spray Tests

The salt spray cabinet and its use are too well known to require description here. In paint evaluation, little use is made of this test in Aluminum Research Laboratories although the equipment is available if needed. The salt spray test is a very good test to determine the resistance of paint coatings to salt spray, but it does not evaluate the simultaneous effect of light and weather.

Resistance To High Temperatures

Aluminum paint made with special vehicles has long been recognized as an excellent paint for use on surfaces that may be heated. There is, moreover, considerable variation in the performance of some of these so-called "heat resisting aluminum paints." In testing these paints the following procedure is used. One coat of aluminum paint is applied by brush or spray on clean steel panels, 4 in. x 9 in. x .0245 in. The paint is allowed to air dry overnight and the panels are then heated to 1000 degrees F for 8 hours. After cooling, a portion of one of the panels with each paint under test is bent through 180 degrees over a quarter inch rod. A good paint will show no marked darkening, blistering, rubbing or smudging of the finish and will not crack or flake from the bent portion of the panel when submitted to this test. A second heated panel of each paint, after double coating the edges with a durable aluminum paint, is placed on the roof for atmospheric exposure. Satisfactory paints for outdoor use will not show failure within three months. Figure 21 shows a group of panels that have been so tested. It will be noted that only a few of the painted panels are free from failure and some of the coatings show rather severe breakdown after three months' exposure.

Other Tests

In addition to the various types of exposure tests

which have been discussed, there are a number of laboratory tests that are used to evaluate paint coatings. One of these is the abrasion test. For this purpose the ASTM Abrasimeter is used following the technique described in ASTM Specification D658-44. A photograph of this apparatus is shown in Figure 22. The abrasion resistance of the coating is measured by the number of grams of 200 mesh carborundum required to wear through the film. It is usually reported in terms of abrasion resistance per mil of film thickness. Values ranging from a few grams to several hundred grams have been observed for different paint coatings.

Chemical resistance is determined either by immersion in the chemical in question or by means of spot tests. Acid spot tests of 30 minutes' duration usually yield information of value. Sometimes the painted panels are exposed to the vapors of the acids or other chemicals to determine performance under the conditions of test.

Bend tests on a conical mandrel tester (ASTM Specification D522-41) serve to show the degree of flexibility possessed by the coatings. Kauri reduction tests are also employed for clear varnishes, and in some cases, even pigmented finishes.

Reflectivity for light is also sometimes measured. Total reflectivity for white light is measured on a Taylor-Baumgartner Reflectometer. Apparent reflectance is measured on a Hunter Multipurpose Reflectometer; the specimen is illuminated at 45 degrees to the normal and measured at 0 degree to the normal. This gives a measure of diffuse reflectivity.

Performance Is Criterion

Many testing methods are available to evaluate paint coatings. Even after the tests are completed, the real criterion of the value of the paint is its performance in service. Only after years of experience with various paints in both laboratory and service tests is it safe to hazard an opinion about the merits of any new type of paint from the results of laboratory tests alone.

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Robert Mallet—Pioneer Corrosion Engineer*

By WILSON LYNES*

Abstract

An appraisal has been made of the reports of Robert Mallet on the action of water and air upon iron and steel, based on tests made in 1838-42 under the sponsorship of the British Association for the Advancement of Science. These reports are of interest for their revelation of the remarkably clear, comprehensive and practical knowledge of corrosion possessed at that early date. A brief review of some aspects of progress in the understanding of corrosion from 1800 to the present is also given.

IT MIGHT be assumed that organized corrosion testing originated with the formation in 1906 of Committee U (now A-5) of the American Society for Testing Materials. Such is not the case. Long before this, the British Association for the Advancement of Science appropriated a sum of money "for the institution of a series of experiments on the great scale on the chemical and mechanical effects and changes produced on Cast and Wrought Iron by the continued action of Sea Water at various temperatures, and of foul River Water whether fresh or salt," reported upon by Robert Mallet in 1838, 1840 and 1843.¹

The subject chosen by the British Association in 1837 was not only of interest scientifically, but of great practical importance. In the preceding 50 years, iron in its various forms had been adopted upon a scale hitherto unknown and at a rapidly increasing rate, to construction of harbors, ships, bridges, railways, and innumerable other contrivances.** It became important, therefore, to inquire: "What was the durability of the apparently hard and intractable material employed? What were the forces likely to occasion its destruction? How would they act? What would be the results? And what were the means of arresting their progress?"

The present significance of Mallet's admirable reports, which comprise 198 pages, lies not in their priority, but in their revelation of the comprehensive knowledge of factors relating to corrosion then existing and the extent of practical application of scientific principles to corrosion testing and control.

Existing State of Knowledge

The period between the discovery of the galvanic battery in 1800†, and the experiments of Robert Mallet in 1838-42 had been marked by intense activity and brilliant advances in the new science of electrochemistry.^{3,4} Among the notable accomplishments bearing on corrosion were: Electrochemical theory of corrosion,^{5,7,8,9,10} differential solution concentration

cell,^{11,12} metal-metal oxide and differential stress cells,¹³ and Faraday's Law.¹⁴

The metals were arranged in order of decreasing activity, and it was shown by de La Rive¹² that many reversals of polarity occur as a result of changing the dilution or composition of the electrolyte, or with time. It was recognized by de La Rive and others that any list of metals in their order of electromotive force should be constructed with reference to a specific electrolyte.

According to the more generally accepted versions of the electrochemical theory of corrosion, local galvanic couples were formed between the metal and its impurities, or the metal and its oxide, but Sturgeon¹⁰ considered that "the surfaces of the purest metals are unequally electrical,* and consequently electropolar," and Faraday,¹⁵ in order to disprove the contact theory of Volta, made numerous experiments involving a single metal only, in which a potential difference was obtained by differences in concentration or temperature of the electrolyte.

Among advances of a more practical nature, Hall¹⁶ demonstrated the necessity of dissolved oxygen for appreciable corrosion or iron in water at ordinary temperatures and Davy¹⁷ found the same necessity of oxygen for the corrosion of copper in sea water. The inhibitive effect on iron of alkaline compounds in water containing oxygen was observed by Hall,¹⁸ and investigated in detail by Payen and others. The principle of cathodic protection developed by Davy,¹⁹ led, among other things, to the commercial production of galvanized iron at the end of the period under discussion.

Later Concepts of the Nature of Corrosion

Such, in part, was the background of knowledge when Robert Mallet conducted the experiments entrusted to him. Shortly thereafter, the role of the

*Submitted for publication August 10, 1953.

*Research Dept., Revere Copper and Brass, Inc., Rome, N. Y.

**In 1800, Great Britain produced about 200,000 metric tons of pig iron; in 1840 production had increased to 1,400,000 metric tons, with most of the increase occurring in the decade 1830-40. During this period production in Great Britain was about one-half of the world's production.²

† "... The galvanic battery of Volta not only gratified the passion for novelty by the curious effects it produced, but likewise awakened the love of investigation, by definitely exhibiting the analogy between galvanism and common electricity.

"... The discovery of the chemical agencies of galvanism has led to researches which finally cannot fail to elucidate the philosophy of the imponderable or ethereal fluids. The year that is just passed will long be distinguished in the history of science; seldom has physical investigation been pursued with greater ardour"

* "The positions of the polar points on the surface will frequently change during the dissolution of the metal on various accounts; depending upon the deposition of oxide, formed by the first and subsequent currents, the texture of the metallic points, their polish as they are arrived at during the process, their crystalline structure, and perhaps upon many other causes of a still more recondite nature."

differential oxygen concentration cell in promoting localized corrosion was made evident from experiments by Adie,²⁰ and the cell was studied in detail by Viard²¹ in 1852.

It seems strange that during the remainder of the nineteenth century, not only was there lack of significant advance in the application of scientific principles to corrosion, but many of the earlier applications were lost sight of and their places usurped by fallacies such as the acid, direct oxidation and direct chemical action theories of corrosion. As a result, the present understanding of the fundamental factors is based mostly on rediscoveries and elaborations made during this century by Palmaer, Whitney, Walker, Aston, Evans, McKay and others.^{3, 22, 23} These investigators had the advantage to be gained from intervening advances in electrochemistry, such as the theories of electromotive force, ionization and thermodynamics of conducting solutions, as well as measurements of overvoltages, which permitted a more quantitative treatment of corrosion than hitherto had been possible.

Universal acceptance of present day concepts was slow in developing. As recently as 30 years ago, the fitness of the electrochemical theory to explain the processes of aqueous corrosion was the subject of controversy^{24, 25} and until about 1915²⁶ the viewpoint of the proponents of the revived electrochemical theory was that electrochemical corrosion is caused exclusively by galvanic currents produced by the metal and its impurities, or by contact of dissimilar metals, or by other causes related to the metal. In the 1920's the idea that heterogeneity of the environment is also an important source of corrosion currents became generally accepted and the role of protective films as deterrents of corrosion was properly stressed.

The Reports of Robert Mallet

The reports of Robert Mallet are so comprehensive and extensive that no summary of reasonable limit can adequately convey the contents. Therefore, the following account is comprised of excerpts of details considered to be among those of most interest.

The materials tested comprised 77 different sorts of cast iron from most of the principal iron works of Great Britain, 17 kinds of wrought iron, 7 kinds of steel, 10 different organic coatings, galvanized iron, and zinc paint. The organic coatings comprised caoutchouc varnish, copal varnish, mastic varnish, asphaltum varnish, white lead paint, Swedish tar, hot coal tar, wax and tallow, turpentine varnish and drying oil.

In the first course of experiments, the cast iron and organic coatings were exposed for 387 days in clear sea water at 46-58 degrees F and at 110-125 degrees F, in polluted sea water, in fresh clear river water, and in polluted tidal river water. In the second course of experiments, the same materials were exposed for an additional 732 days and the wrought irons, steels and metallic coatings were tested concurrently under the five different conditions of exposure. In addition, the cast irons were exposed to the atmosphere of the City of Dublin for 539 days.

The purpose of the second period of exposure of the cast irons and organic coatings was to permit prediction with greater certainty the actual loss of metal after long periods of exposure and to determine whether the corrosion rate changed with time, since "it became obvious in course of inquiry, that the original state of the metallic surface when first exposed had much to do with its rate of corrosion, and that this became subsequently modified as it proceeded, and thus that the amount of loss of metal by corrosion might not follow a law of equidifference, but might increase or decrease in rate upon continued exposure."

The cast iron specimens were in the form of parallelepipeds, 5 x 5 x 1-inch and 5 x 5 x 1/4-inch. The object of the two thicknesses was to test the effect of the differences in structure and in proportion of "skin" to metal so produced. Also included were specimens, the "skin" of which had been removed by machining.

The specimens were weighed to within one grain and enclosed in wooden boxes, which permitted free access of water, each specimen being held fast at the corners in a separate cell of veneer of varnished oak. The reason for this arrangement was that "it appeared not impossible that if several different sorts were inclosed in electrical continuity in the same box, grave errors might be introduced into the results by the iron least acted on standing in a negative relation to those more rapidly corroded, and increasing the action of the sea or other water upon them, and at the same time being themselves preserved to a certain extent. By a few preliminary experiments with the galvanometer, this was found to be a correct view—it was found that of any two different irons, the harder was always in a negative relation to the softer, which was positive to it, and hence the separation of every specimen became necessary in order to eliminate this source of error."

In each box there was included a single parallelepiped of wrought iron, cut from the same bar, called "The Standard," and it was proposed that the remainder of it be deposited with some learned body, "so that any future experimenters on novel makes of iron, or upon foreign ones, can, by reference to the standard bar . . . make their experiments comparable with these. Without this precaution the present experiments, although correct, would stand isolated, and be scarcely capable of being even brought into comparison with future ones."

At the end of the test periods, in addition to reweighing the specimens, the character of the corrosion was classified under one of the following terms: 1. uniform; 2. uniform with graphitization; 3. local; 4. local pitted; 5. tubercular.

The results of the tests indicated that "homogeneity of surface and texture, or the contrary, are by far the most important circumstances which may vary the amount of corrosion in cast iron by air and water; that the rapidity of this is not so much dependent upon the chemical constitution of the metal as it occurs in commerce, as it is upon its state of molecular arrangement and the condition of its constituent carbon . . . Voltaic uniformity of the surface is best ob-

tained by slow cooling of the metal when cast, and in all small castings will be much promoted by subsequent annealing out of contact with air, as in the process ordinarily used for decarbonizing cast iron to render it flexible and tough."

The loss of metal by corrosion was, in every sort of water tried, more rapid but less localized, in wrought iron and steel than in cast iron. In general, steel corroded more slowly and more uniformly than wrought iron. As is the case of cast iron, the more uniform the texture of the wrought iron, the slower and the more uniform was its corrosion; small differences in chemical composition having very little effect on the rate of corrosion.

The powerful corrosive action of foul sea water was correctly attributed by Mallet to hydrogen sulfide. He observed that "organic matter in a state of putrefaction is one of the most powerful deoxidizing agents known—so much so, as to be capable even of reducing sulphate of lime in the state of gypsum."

In supplementary experiments, it was determined that, in fresh water, the corrosion of cast iron proceeded the fastest at temperatures varying between 175 and 190 degrees F. It was found further that the rate of corrosion was proportional to the volume of dissolved air at any given temperature, and that, on slowly heating water containing dissolved air from 60 degrees F up to 212 degrees F, the air was evolved in greatest volume at 190 to 195 degrees F. If the water was freed from air, its corrosive action on iron ceased in a closed vessel; but if the vessel was open and very shallow, the heat even of boiling did not entirely prevent the absorption of air, and oxidation proceeded even more rapidly than at a lower temperature. The corrosion of cast iron in fresh and salt water was found to vary inversely with the depth of immersion, in the absence of lateral currents.

On the Nature and Mechanism of Corrosion

Robert Mallet attributed the increase in rate and localization of corrosion of iron with decrease in its homogeneity to increase in the number of galvanic couples on its surface. In cast iron and steel, couples were considered to exist between iron and its graphitic or combined carbon; and in wrought iron between the iron and its incorporated slag. After corrosion started, the corrosion cells due to the structure of the metal were augmented by those between iron and its oxides, "since it has been shown that every metal, iron included, is electro-positive to its own oxides." It was remarked that when the rust formed was sufficiently adherent and dense that it partially defended the metal mechanically from corrosion in spite of its being cathodic to it.

Mallet appears to have been the first to apply the differential solution concentration cell to the corrosion of metals. "It is well known," he said, "that the sea water, during the flowing of the tide, from its greater density, forces itself beneath the river water like a wedge, and slowly and imperfectly mixes with it, hence two strata, one of fresh or brackish water, the other of salt water below it . . . Now Becquerel has proved that a homogeneous metallic surface (a rod or wire for instance) exposed to the action of a

fluid menstruum, will assume a state of electrical tension, provided that the fluid in which it is immersed be of different density in two strata, i.e. of different corrosive power. In fact the metal and the two layers of fluid constitute a voltaic pile of one solid and two fluid elements; hence as one end of the metallic rod will be in a positive state with respect to the other, it will be corroded faster than the other. Now this is precisely the condition of any casting reaching through a considerable depth of water at the mouth of a tidal river. The water is saltier below than above, the part of the casting immersed therein (the lower end of a cast iron pile for instance), will therefore be in an opposite electric condition to that of the portion above, and the amount of corrosion of the positive element due to the kind of iron, and the state of the water, will be further increased or "exalted" by the negative condition of the opposite end, which will be itself in the same proportion preserved. This principle extends to very many practical cases, as to iron plates, etc., partly immersed in a solvent fluid, and partly exposed to moist air, etc.; and it suggests the importance of giving increased scantling to all castings intended to be so situated, to allow for this increased local destruction of material."

Corrosion Protection

The result of the tests on protective coatings led to the conclusion that "zinc paint appears to be, as predicted, an extremely durable covering, more so than any one tried, except the asphaltic varnishes or coal-tar laid on hot; it is desirable its use should become better known, and be extended to all large engineering structures, iron bridges, viaducts, etc. . ."

Mallet recognized that naturally formed coatings might also be protective, and observed that "the coat of oxide of iron formed in fresh water adheres obstinately to the iron, . . . and is not removed in a loose pulverent form with the same ease as it is in the sea water, and hence acts in some degree as a cloak, or partially impervious covering, to defend portions of the metal from further action." He also observed that when zinc is used to cathodically protect iron in sea water, "the surface of the zinc gets covered . . . with a hard crystalline oxide of zinc and of calc-spar, which retards or prevents its further corrosion, and thus permits the iron to corrode."

The previously mentioned experiments on the influence of dissolved air on corrosion rate led to the recommendation of deaeration of boiler feedwater, stated as follows: "It would be desirable that the feed-water of marine boilers were heated to above 190 degrees Fahr. before entering them, and means provided for the escape of the air disengaged, which now enters the boilers and aids much in corrosion. This could easily be done by Maudsley and Field's beautiful arrangement of their feed and brine pumps."

On Protection by Zinc and Zinc Alloys

At the period of publication of Mallet's reports, the preservation of cast and wrought iron by the electrochemical action of zinc was beginning to excite considerable attention, first drawn to it by the views of H. Davy,¹⁹ and subsequently by the experiments of

E. Davy,²⁷ and by the parents of Craufurd²⁸ and Sorel^{29, 30} on hot-dip galvanizing.

Comprehensive laboratory experiments were made by Mallet on the protective powers of zinc to iron and steel in fresh and in sea water, some of which were continued for two years. In one series of experiments, the specimens were immersed at a depth of 12 inches and in another, exposed to the air and covered with a thin film of water frequently renewed. The influence of the ratio of surface of zinc to that of iron was investigated in the range of 4 to 0.00786.

It was found, under conditions of submergence, that the protective power of the zinc was diminished, or nearly destroyed after its surface became covered with a coating of zinc oxide. When the surface of the iron or steel contained rust, the zinc lost nearly the whole of its power of protection even prior to its oxidation, for "the original difference in electric condition between clean iron and clean zinc is so small, that the former ceases to be negative with reference to the latter as soon as it has been rendered more positive by the presence of its own peroxide."

The well-known difference in rapidity of solution between pure and impure zinc, first explained by de La Rive,⁹ induced Mallet to make experiments as to whether the protective power of zinc could be increased by alloying the former with a small amount of another metal higher or lower in the electrochemical scale. It was found that addition of elements cathodic to zinc decreased its protection to iron in sea water; whereas, the addition of an element anodic zinc increased the protection of the iron.

Galvanic Corrosion

Numerical measures were obtained of the acceleration of corrosion of wrought iron when in contact with copper, brasses, tin bronzes and tin. Tin produced the greatest acceleration of corrosion of the iron,* followed in decreasing order by the tin bronzes, copper and the brasses.

It was recommended that when copper or a copper alloy must be in contact with iron, as in the flanges of sea-cocks, etc., in steam vessels, that a thickness of patent felt, saturated in boiled coal tar or in wax, or other non-conducting substance, be interposed.

On the Protection of Iron Ships

The durability of iron ships became one of the most important questions involved in the inquiry sponsored by the British Association on the action of water and air upon iron, because of the rapid increase in their use which occurred during the progress of the corrosion investigations.

Robert Mallet devised a method designed to prevent corrosion and fouling of iron vessels, involving the application of three coatings. The first was a zinc-mercury alloy coating, the second, an organic coating, and the third an anti-fouling paint.

The plates or other pieces of iron or steel were pickled, washed, scoured and immersed in a liquid

composed of equal parts of saturated solution of zinc chloride and of ammonium chloride. From thence the pieces were immediately immersed in a molten bath of zinc-mercury, containing about 1.5 percent mercury, to which had been added 0.05 percent sodium.

The completed hull of the vessel, which was entirely coated with the zinc-mercury alloy including the rivets, was then covered with varnish made as follows: 50 pounds of asphaltum, 16 pounds of red lead and litharge in equal proportions, and 10 imperial gallons of drying linseed oil were boiled together. In a separate vessel, 8 pounds of gum anime, 2 imperial gallons of drying linseed oil, and 12 pounds of caoutchouc softened by coal tar naphtha were melted. The contents of the latter vessel were then added to that of the former and the whole boiled until tough and ropy. When cold, it was thinned with 30-35 imperial gallons of turpentine. It was recommended that it be applied with a spatula, as a brush left minute air bubbles.

For the last operation, a thick paint was made with drying linseed oil, red lead and barium sulfate, and a little turpentine. To every 100 pounds of the paint, there was added 20 pounds of copper oxychloride and 3 pounds of a mixture composed of hard yellow soap, melted with an equal weight of resin and a little water. The purpose of the resinous soap was to give the paint a slight degree of solubility in water.

The development of the anti-fouling paint was based on experiments made by Mallet on the effect of metallic salts upon some common marine organisms. These experiments showed that contrary to the opinion of Davy,³¹ copper salts were poisonous to fouling organisms, being most so of all of those tried.

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Paint vs Corrosion—Some Aspects of the Problem In the Gulf Coast Area *

By V. B. VOLKENING*

Introduction

IN THIS DISCUSSION, no positive and clear-cut answer to the general problem of paints and painting as a method of corrosion control will be given. Nor will there be an answer to the specific problem existing in the Gulf Coast region.

The intention of this paper is to ask more questions—rather than give answers.

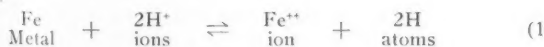
Material presented herein has been drawn from experience in the use of paints in one particular group of industrial plants, those comprising the Texas Division of the Dow Chemical Company. It indicates the scope of the overall paint problem by touching on some environmental factors and on some factors created by the division itself. Next is mentioned some steps taken in attempts to solve existing problems and, finally, some ideas on steps others may well take to the same end.

Begin with one basic concept and some statistics.

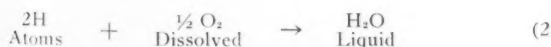
Basic Concept

Corrosion mitigation by use of organic coatings—or paint—is such a controversial subject that it is well to review some basic and accepted facts. The simplified equations reflecting the mechanism of the corrosion of iron¹ say simply that when moisture and oxygen are present together, they can corrode iron or steel.

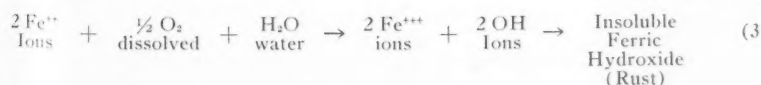
Primary Reaction



Destruction of Hydrogen Film



Final Reactions



This equation says also that corrosion is an electrochemical process. Although not shown, there must be a transfer of electrons for the corrosion reaction

Abstract

After briefly mentioning the theory of metallic corrosion the author relates the problems encountered by Dow in protecting its Gulf Coast plants against atmospheric corrosion. Examples of coating successes and failures are given. The method which Dow uses of testing paint cooperatively with the manufacturer is explained. The author points to advantages of proper surface preparation and suggests too little attention is paid to educating the 350,000 painters who apply coatings to metals in proper application techniques and that paint manufacturers, paint manufacturers' associations and the National Association of Corrosion Engineers might find the organization of schools for painters a worthwhile activity.

to proceed and thus establish the electrochemical nature of corrosion. The definition accepted by the corrosion engineer is, "Corrosion is accompanied by electrical currents flowing for perceptible distances through the metal because of spatially separated anodic and cathodic areas."²

All are familiar with these fundamental concepts of the nature of corrosion. The concepts become more complicated and more subject to controversy as additional variables make their appearance.

This discussion is concerned with organic coatings, by the use of which prevention of the reaction indicated in Equation 1) is sought by placing a barrier between the metal and its environment.

Basic Statistics

All are familiar with the fact Uhlig³ estimates the annual direct cost of corrosion in the United States, including the cost of corrosion control, to be \$5,427,000,000. Less familiar, perhaps, is his estimate on the annual expense for protective organic coatings and their application. This cost is \$2,045,000,000. Stated in percentages, paints and painting account for 38 percent of the annual national cost of corrosion and corrosion control.

In other words, out of every dollar spent for all corrosion prevention materials and methods combined, including galvanized steel, nickel alloys, cop-

per alloys, stainless steels, boiler water conditioning, internal combustion engine corrosion, etc., 38 cents is spent on organic protective coatings and their application alone. Thus, paint is the most frequently employed single corrosion combating tool today. This can be interpreted as a credit to the paint industry and it can also be interpreted as a challenge.

* Presented before a joint meeting of the Houston Paint Varnish and Production Club and Houston Section, National Association of Corrosion Engineers at Houston, Texas, October 14, 1952.

* Chemical Engineering Department, The Dow Chemical Company, Texas Division, Freeport, Texas.

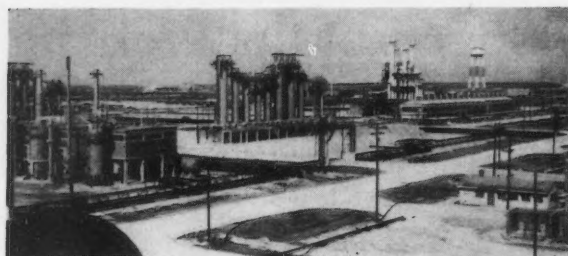


Figure 1—View of The Dow Chemical Company plant at Freeport.

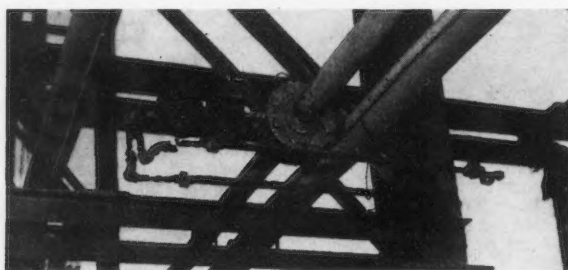


Figure 2a—An instrument air line that corroded in two in six years.

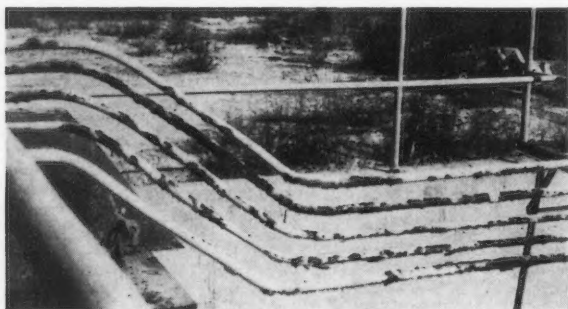


Figure 2b—Badly damaged small piping.

TABLE 1—Corrosiveness of Selected Atmospheres Compared to Freeport, Texas, Location*

Location	Types of Atmosphere	Corrosiveness
Khartoum, Egypt.....	Dry Inland	1
Singapore, Malaya.....	Tropical Marine	9
Freeport, Texas, U.S.A.....	Rural Marine	19
Kure Beach, N.C., U.S.A.....	Marine—800 ft.	38
Freeport, Texas, U.S.A.....	Marine	39
Pittsburgh, Pa., U.S.A.....	Industrial	65
Sheffield, England.....	Industrial	78
Frodingham, England.....	Industrial	100
Kure Beach, N.C., U.S.A.....	Marine—80 ft.	470
Freeport, Texas.....	Industrial-Marine	501

* C. P. Larrabee. Corrosion of Steels in Marine Atmospheres. *J. Electrochem Soc.*, 87, 163 (1945).

This challenge is one of the points to be discussed later.

Making certain assumptions (which may contain some errors), consider the following: By working 40 hours a week, 52 weeks a year at \$2.00/hour, a painter can earn \$4160 annually, or approximately \$350 per month. Divide \$1,460,000,000, the cost of corrosion for application labor of paint materials, by the painter's annual income, \$4160, and the resulting

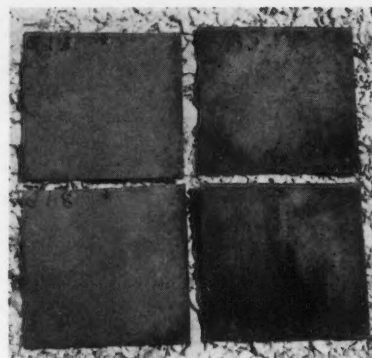


Figure 3—Effect of humidity on painted panels. Panels at right were exposed without heat. Left panels had an infrared lamp focused on them from the rear.

figure is 350,000, as an approximation of the number of painters working toward corrosion prevention.

Some Paint Problems Experienced In Dow's Texas Division

Add one more statistic, a round one, to bring into the discussion the paint problems and practices in the Dow Chemical Company's Texas Division plants. The division's stake in paints and painting as a corrosion control measure is approximately \$1,000,000 a year. We believe in paint; we use paint. Figure 1 is a view selected to give some idea of the extent of the division's painting problem.

An environmental factor which is a major element in all considerations of paint and painting by the division is atmospheric corrosivity.

The plant location about a mile inland has corrosion rates equal to the ratings on racks only 800 feet from the ocean at Kure Beach, N. C., where the Seahorse Institute conducts tests. And at the central test site in the plant, the rate is 501—worse than that of the 80-foot racks at Kure Beach. (See Table 1.)

A more graphic presentation of the severity of the environmental factor can be seen in Figures 2a and b, showing an instrument air line broken in two by atmospheric corrosion in six years and badly damaged small diameter piping.

Severe corrosion, of course, is not confined necessarily to small objects. But, like corners, edges and inaccessible spots, it underlines the general problems involved in the use of paint to combat corrosion.

Another environmental factor is humidity. In the plants of the Texas Division, humidity reaches 100 percent nearly every night. When it does, corrosion of iron in water in the presence of oxygen is possible. Certainly humidity contributes materially to the relative corrosion rate of 501 determined by exposing bare iron specimens for test purposes.

As further illustration of humidity's effects, compare the four test panels shown in Figure 3. Each was prepared, primed, finished and exposed as nearly alike as possible—with one difference. An infra-red bulb burned behind the two panels on the left and prevented much moisture condensation. The right hand panels were exposed to the full attack of the humidity.

Figure 6—Essential Data Sheet—Protective Coatings

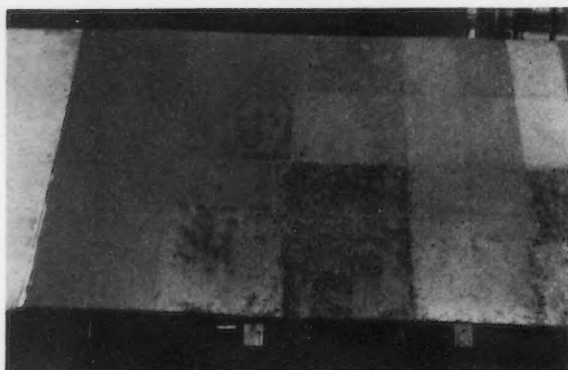


Figure 7—Showing how paint performance is affected by surface preparation. After 14 months' exposure samples in bottom half, applied over wire-brushed area, have deteriorated much more than those in upper half, applied over sandblasted area.

example, a better, more decorative enamel for caustic drums was needed. Drum enamel specifications shown in Table 2 were submitted to a number of local paint manufacturers, which returned answering samples.

The samples reflected, in highly interesting fashion,

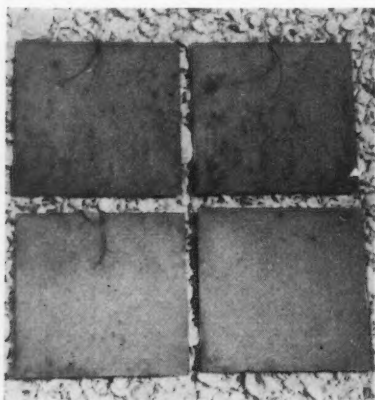


Figure 8—Dow's experience demonstrates advantage of surface wetting agents' use over phosphoric acid pretreatment. Panels at top were given two proprietary phosphoric acid pretreatments while bottom two received surface wetting agent pretreatment.

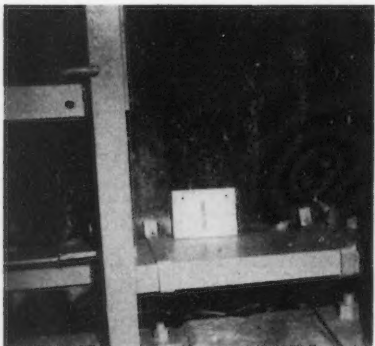


Figure 11—Same site as in Figure 9 after finishing.

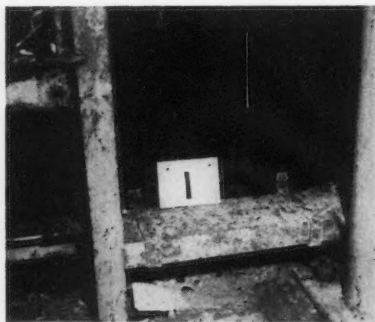


Figure 9—Interior test site before repainting.

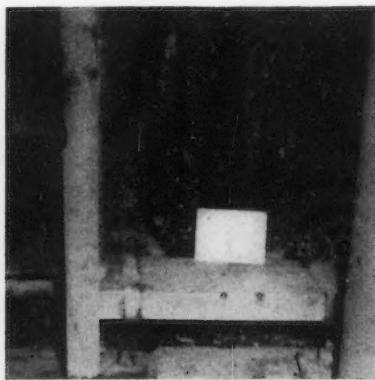


Figure 12—Same site as in Figure 9 after 25 months.

the varied approaches taken to the problem. Types of vehicles used and named in Table 3 varied from oil types with resin reinforcement to chlorinated rubber and modified vinyls. Other variations included: Drying times from five minutes to overnight; costs from 61 cents to \$1.37 per pound of solids, or from 5.5 cents to 9.3 cents for material per painted drum; and dry film thickness from 0.3 to 1.5 mils.

Table 3 gives results. The measure of protection secured seems to be a matter of using quality ingredients applied at the proper film thickness. Another reasonable conclusion is that a paint formulator's experience determines his ability to supply material for service in a stipulated environment.

Some Steps Taken to Solve Paint Problems

In seeking a solution to these environmental and self-created problems the Texas Division has followed two main courses. First, is an extensive paint testing program and second, certain standard practices have been adopted in the paint application program.

Cooperative Paint Testing

Because of the complex nature of the problem, involving colors new to this type of environment and an unusually severe atmosphere, it was decided to solicit all possible aid. Deciding that the best approach lay in cooperative effort, a program of testing

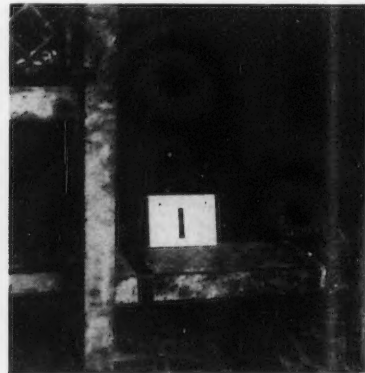


Figure 10—Same site as in Figure 9 after cleaning with pneumatic buffers.

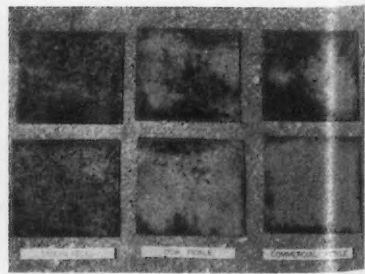


Figure 13—Comparison of (left to right) sandblasted, commercial pickle and Dow pickle results after 17 months' exposure.

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coating materials cooperatively was started. "Cooperatively" is defined by Webster as "operating jointly to the same end." In this program, the manufacturer furnishes the paint of his formulation and supervision for application. Applications are always carried out according to manufacturer's directions. Dow supplies the test site, the test panels, the painter, the corrosive environment and whatever incidental materials and services are required. Evaluation readings of the exposed panels are made jointly. Copies of rating records are exchanged. Film thickness measurements are made of primer and total system by means of an Elcometer dried film thickness measuring gauge.

In Figure 5 an overall view of Dow's central paint test farm is shown. This location in the heart of the plant where the relative corrosivity of 501 gives quick results. Each of the cooperative panels is covered generally with one manufacturer's products with a few controls of known performance. As a rule one coat of primer is applied horizontally and two finish coats vertically. This usually results in a total film thickness ranging from 2.5 to 4.5 mils.

On each material, primer and finish coat, the manufacturer furnishes the data requested on the essential data sheet shown in Figure 6. These data are confidential between the manufacturer and Dow and serve one very important purpose. They assure Dow as a consumer, that the product tested for 12 to 18 months on panels and another 24 months or longer in the field will be identical to the product supplied if called for. An assignment of a new code number and retesting is insisted on if changes are made in the formulation. Retesting reveals what these changes mean, not in Florida, California, or elsewhere, but in Dow's plant in Freeport, Texas. By operating closely in this manner, directly with the laboratory of the manufacturer, Dow is able on occasion to go along with minor variations when certain materials are not available.

One cooperative test involving 1804 6 x 6 inch panel paintouts, was applied in eight different plant areas and took 2½ weeks to finish. Another test, with another company involved panels sand blasted at the top and wire brushed at the bottom.

Cooperative testing establishes a sympathetic attitude on the part of the consumer which ordinarily might not be found. It builds a confidence between buyer and user rarely seen in this relationship. This arrangement, the writer believes has worked satisfactorily for the manufacturers and their benefits have been proportional to the amount of effort they have expended. Dow seeks only coatings which last.

Surface Preparation

Although it has not been stressed it is well to point out that most test panels were sandblasted before painting. Figure 7 shows that the wire brushed bottom half of the panel is breaking down first after 14 months' exposure.

Figure 8 gives a comparison of two proprietary phosphoric acid preparations at the top and two surface wetting materials at the bottom over wire brushed panels under a marine red lead primer and

two finish coats. The panel at the bottom right was prepared with boiled linseed oil. Surface wetting of pitted hand cleaned steel has been found essential. Dow's practice is to use primers with adequate free oil plus inhibitive pigments in an effort to get results equal to phosphatizing. Another approach when slow drying cannot be tolerated is to use the faster drying vinyl metal conditioners, a practice generally followed when contaminating materials are present in the environment.

Typical Application Is Pictured

Figures 9 through 12 show what happens at a typical location. Figure 9 shows what the selected spot looked like initially. Figure 10 shows it after cleaning by mechanical buffers. Figure 11 shows the same location just after painting with five coats of vinyl paint including the metal conditioner. Figure 12 shows the appearance of this job 25 months later.

Two things are shown in Figure 12 which indicate improvement is needed. One is that the steel has not been given attention in time to avoid another expensive surface preparation job before repainting. The other is that this job should have lasted five years.

Surface Preparation Important

Surface preparation is such an important part of the job that it must be given special emphasis. Sandblasting and pickling are standard surface preparations given to objects to be galvanized or porcelain enameled. Yet when organic coatings are used this important foundation step often is slighted or sometimes omitted completely.

Mill scale must be removed before painting just the same as rust is removed. Mill scale on new steel acts as cathode and the iron exposed at the discontinuity as anode³ when a circuit is completed through a microscopic film of moisture on the surface. With a difference of potential existing, the anodic areas where iron goes into solution can become a pit and the iron oxide formed begins to grow in size. In humid atmospheres and particularly on submerged structures, this process continues even after painting, because there is no absolutely impervious film and the resulting blister soon causes a break in the film.

Specifications at Dow for handling new steel call for sandblasting to bright metal or removal of the mill scale by means of an inhibited hydrochloric acid

TABLE 3—Results of Black Drum Enamel Test
Range of Products Submitted

VEHICLES	Drying Time (Tack Free) Minutes	MATERIAL COST			
		Per Gallon	Per Lb. of Solids	Per Drum	Film Thickness Mils
Reinforced Oils, Styrenated Alkyds, Chlorinated Rubbers, Modified Vinyls, Etc.	5 to Overnight	\$1.95 \$2.68	\$0.61 \$1.37	5.5-93c	0.3-1.5
FINAL EVALUATION					
Protection					
Best Protection...	105	....	76c	9.3c	1.2-1.5
Good Protection & Quickest Drying...	15	....	72c	7.4c	0.9-1.5
Good Protection & Glossiest.....	Overnight	....	64c	5.5c	0.8-1.0

solution. When the surface is prepared by pickling with HCl, the steel is given a final dip in a dilute phosphoric acid solution. This is usually followed by two coats of a mixed pigment primer high in red lead and two finish coats of paint to bring the minimum film thickness to 5.0 mils. The finish coats are either a styrenated dehydrated castor oil or butyl phenolic with appropriate pigmentation.

Dow's acid pickling plant includes a caustic bath for degreasing, hydrochloric acid tanks for descaling and a phosphoric acid tank for application of phosphate coatings, with water rinse tanks between.

For handling large volumes of pipe and certain structural members Dow favors pickling. It appears to be more economical and provides a more uniform corrosion resistant base for organic coatings. Figure 13 compares a series of sandblasted, commercial pickled and Dow pickled panels after 17 months' exposure on test racks. The paint systems and exposure periods were identical.

What Can Paint Industry Do?

Now what does Dow as a user of organic protective coatings expect from the paint industry in the way of help?

It seems the industry can move in one of two major directions, one of which would be to perfect materials that can be applied under water and over rust, so that surface preparation, the most expensive part of paint application, can be eliminated. This may have been accomplished already; at least, the writer is aware that claims have been made that both are possible. However, Dow has investigated a few products with rather extensive claims and has found them mostly exaggerated. The writer does not believe this is the direction the industry should be expected to go nor does he think it the direction the industry intends to go.

The other direction is more involved and more difficult to explain. It may be more complex than the manufacture of paint itself. The author believes most significant advances can be made through research and education. He thinks also that many tools are available to scientists today that certainly should be put to use in the paint industry. What is now art must be replaced by scientific method which consists of a good deal more than making a few simple physical measurements before canning.

Since Dow is interested in color, it is natural to suggest wider use of the spectrophotometer for closer color matching. This instrument, now used for color control in the plastic industry, could eliminate the human error in paint color matching which now varies from person to person and batch to batch.

Another tool being used to some extent by pigment manufacturers is x-ray diffraction equipment. For determining the differences between rutile and anatase titanium dioxide and various other salts, such as basic zinc chromates, etc., this instrument is invaluable.

One of the most interesting instruments known to the writer is the electron microscope. Some work⁶ has been done indicating that pigmented films contain relatively large areas void of pigment, suggesting focal points for breakdown. If correlations of this

nature can be established, it might save many hours now devoted to panel and field testing.

The adhesion problem seems to be another field worthy of research effort to determine its fundamental nature. Some work⁷ using ultrasonic vibrations to measure the forces of adhesion has been done. Other methods have been described recently.

There is no inference that any of these methods are either new or not being used to some extent. The writer intends to point out that most of this type of research has been done in colleges and universities. Although some additional work is underway at the direction of the raw materials manufacturers and some is being done by manufacturers of finish coatings the writer feels that the volume of work is small in comparison to what is being done elsewhere.

A real challenge is presented to manufacturers in this area facing problems peculiar to the Gulf Coast. They should be solved here just as it is logical for research being carried on in Chicago, Detroit or Cleveland to consider problems which arise as a result of and are peculiar to industry there.

Major needs in the Gulf Coast are quite different, however, from those in some other areas. Large chemical plants, and petroleum refineries which process raw materials to intermediates and finished products in volume came to the Gulf Coast because of abundant raw materials and a climate conducive to outdoor operations. Protection must be given the millions of dollars invested in steel in these large and small plants. The coatings need to be tailor made because the conditions of application and finishing are quite different from those where applications are made in air conditioned spray rooms and paint is baked out with infrared heating equipment. This is the challenge the writer hopes paint manufacturers of the Gulf Coast will accept.

Painter Is a Key Man

Much has been said about the corrosion engineer, the researcher and the paint manufacturer. But the painter, the man behind the cleaning tool, brush or spray gun, actually directs the last rites of the paint as it is laid to rest. He is important because if he fails to paint properly, all the good work of the manufacturer in formulating and testing has gone for naught.

Consider the problems the painter faces and how he solves them. Most painting for corrosion control is done with spray equipment. But the paints vary: Some dry rapidly by solvent evaporations; some dry slowly; some are designed for application in thin mist coats. What type of gun, suction or pressure, is best for each variety of paint? What needle, what cap goes on the chosen gun? How many feet of hose can be used between the pot and the gun without interfering with proper atomization?

How many men operating paint guns know the right answers? Some, being human, may not care to know but the majority would like to have the added knowledge that would help them do better jobs.

Education Is Indicated

Since education of the painter seems to be indi-

cated, it may be well to ask who should do the educating. Who stands to lose the most through lack of painter education? Men in the paint manufacturing industry are probably well aware that poor results are usually charged to one single cause—the paint. And poor results with a paint generally stir but one thought in the mind of the user—"Try a different product next time." If this analysis is valid, the manufacturer of good paint is the big loser in poor application. He may stand to gain considerably by acting to improve application knowledge of the painters handling his product.

What can be done? Sending 350,000 painters to school to learn spraying techniques, the handling of vinyls, the application of catalyzed epoxies or phenolics is impractical. But the school might be taken to the painters, in the equivalent of seminars or clinics. Instruction, in one or more sessions, could deal with both the usual and the special paints and equipment being used in the particular region.

Manufacturers of paint and equipment could work together in providing such instruction. A common meeting ground might be found through the Paint and Varnish Production Club. Perhaps the National Association of Corrosion Engineers could be called upon for advice on what engineers believe is needed. But regardless of sponsorship, these sessions should be much more than a brisk demonstration in the use of a spray gun. No one would resent a let-down of this kind more than the painter who wants information that will help him do a better job. Give him that and

also perhaps a certificate attesting his accomplishment in improving his craftsmanship and there has been enlisted a strong assistant in the solution of paint problems.

This discussion certainly has not covered all the avenues open to progress. Just as certainly it has not covered all existing problems. While there is no magic elixir, neither is there a situation so catastrophic as to call for magic. Much work remains to be done in the field of paint versus corrosion. Promising results appear to lie in:

1. Close, constant and truly cooperative effort between manufacturer and user.
2. Increased research work by the manufacturer to solve the many problems existing in the localities he serves.
3. Education, through cooperation and research to include everyone involved in the application of organic protective coatings.

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The Measurement of Electrode Potentials*

By NORMAN HACKERMAN*

THE MEASUREMENT of the potential of a metal immersed in a solution is, in fact, the measurement of the potential of a cell consisting of the metal-solution as one electrode system and a reference half cell as the other. Cell potentials can be measured by a voltmeter, a potentiometer, or some combination of either of these with a tube circuit. In corrosion studies the measured potentials usually need be determined only to ± 10 mv, and rarely to better than ± 5 mv.

Reference Electrodes

A useful reference half cell should be readily reproducible without resort to highly specialized materials or techniques and should provide a steady potential when only minute amounts of current pass through it. For field use it should be rugged and portable. There is some advantage if it exhibits a potential predictable on the basis of the Nernst equation,

$$E = E^{\circ} + \frac{RT}{nF} \ln \frac{a_{\text{oxidized}}}{a_{\text{reduced}}}$$

(See any standard physical chemistry text for details concerning this equation.)

Reference half cell potentials are known relative only to the arbitrary zero value assigned to the standard hydrogen half cell. This is perfectly satisfactory, however, because all metal potentials measured can be compared on the same basis. Actually, in corrosion measurements this is not often too important because in most cases the point of interest is not the value itself but the effect of some variable in changing the metal potential, e.g., the effect of a temperature change or of an inhibitor.

For thermodynamical purposes it is desirable to use reference half cells of small temperature coefficient. However, because these are rarely as much as 1 mv per degree Centigrade, this precaution is unnecessary for the most part in measuring corrosion potentials. Thus, if in the worst case the temperature varied as much as 5 degrees C between measurements, no significant error would have been introduced.

Another source of error may be introduced by potentials which exist across liquid-liquid boundaries. In most cases the reference half cell solution differs considerably in composition from that of the metal-

Abstract

A few half cells of interest in corrosion measurements are described in terms of their preparation and use. Brief descriptions of potential measuring devices and their principles of operation are also given.

solution electrode being studied giving rise to so-called liquid junction potentials. Again, however, these are normally smaller than the precision with which corrosion potentials need be measured.

Calomel Half Cell. The calomel half cell consists of a few ml of redistilled metallic mercury overlain first with a thin paste of chemically pure mercurous chloride (calomel) and then by a chemically pure potassium chloride solution. The paste is made by mixing the solid calomel with a small volume of the KCl solution. The solution is either 0.1 N, 1.0 N, or saturated aqueous KCl. Contact to the measuring circuit is made with a wire (often platinum) extending from the mercury in the bottom of the vessel. Contact with the solution is made via a side arm attached to the vessel or by means of a leaky sleeve at the bottom of the vessel.

There are numerous variations in the shape of the electrode vessel but basically a straight tube 1.5 to 2.0 cm in diameter and about 15 cm long is all that is necessary. The metal lead can be sealed into a smaller glass tube which passes through a stopper at the top of the tube, or it can be sealed directly through the bottom of the vessel. In either case it should make contact only with the mercury.

For corrosion potential purposes the saturated calomel half cell is most useful. It has the highest temperature coefficient of the three commonly used half-cells but still not so high that it cannot be tolerated if variation of 5 mv or more is suitable. It is the easiest to prepare because the solution is made simply by saturating water with the salt. It has some minor disadvantages such as crystallization in the side arm type which raises the circuit resistance or "freezing" of stopcocks that may be included on the cell. If the half cell is to be used with a solution which does not contain chloride ions, it is best to insert a salt bridge between the two. The salt bridge may be made from a glass U-tube of about 7 mm diameter filled with a hot one percent agar sol saturated with KCl. On cooling, this sets to a gel and retards material transfer between the calomel vessel and the other half cell vessel. Since the agar sol shrinks when it gels, a concave space may be left at either end of the tube. If so, air is readily trapped

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and an inadvertent and undesirably large resistance is introduced. Therefore, it is best to fill the U-tube so that the level stands above the ends of the tube. This is easily done because of the high viscosity of the agar sol. Air bubbles trapped in the side arm of calomel cell vessels give rise to the same difficulty and must be avoided.

The calomel electrodes are cathodic with respect to the standard hydrogen half cell and the saturated half cell has a potential of +0.2420 v, in the sign convention most often used in this type of work. (It is given as -0.2420 in some of the chemical literature published in this country.) The temperature coefficient is -0.00076 v per degree Centigrade at 25 degrees C, that is, the potential becomes less positive by about three-quarters of a millivolt for each degree increase from 25 degrees C.

Copper, Saturated Copper Sulfate Half Cell. This is not a reference half cell in the thermodynamic sense since it does not operate in a truly reversible manner. Nevertheless, it is a useful tool in certain corrosion potential measurements. It has been used widely in connection with cathodic protection of steel in soils.

The half cell can be made quite simply with a 1.0 to 2.0 cm by 15 cm glass, hard rubber, or plastic tube. It is closed on the bottom by a wooden plug or by a permeable plug, for example a tightly formed roll of absorbent material such as filter paper or porous wood. The tube is filled about one-third full with a saturated aqueous copper sulfate solution plus a small excess of solid copper sulfate to make certain of continued saturation. A copper rod, passing through the cap or stopper, which makes the top closure, completes the half cell. Connection to the potentiometer is made by a lead attached to the top of the copper. Connection to the environment is made by leakage through the permeable plug or around the deliberately loosened lower stopper. The permeable plug system makes for better contact.

The obvious disadvantage of solution loss through the plug when the half cell is not in use can be overcome by placing the assembly in a test tube partially filled with saturated copper sulfate and making closure with a rubber stopper in the annular space between the electrode tube and the test tube.

This half cell is cathodic to the standard hydrogen electrode and shows a potential of about +0.35 v on this scale. The copper, unit activity copper ion half cell is 0.785 v cathodic to the iron, unit activity ferrous ion half cell. It happens that the potential difference between steel in soil and the saturated copper sulfate electrode is about 0.8 v also, but any attempt to provide theoretical justification for this value requires quite a few assumptions. The temperature coefficient of this half cell is small enough so that ordinarily correction need not be made.

The principal precautions to be observed in using the cell are that the copper rod be kept clean and that an excess of solid copper sulfate be maintained in contact with the electrolyte. When it is necessary to prevent contamination of a solution by the copper sulfate, a separate vessel and a bridge should be used.

Other Reference Half Cells. For laboratory purposes in particular it may be desirable to use some other reference electrode. Quite a number of theoretically suitable ones are known but generally they have the serious failing of irreproducibility unless great care is taken in preparing them. One which can be made with not too great difficulty is the silver, silver chloride electrode which can be prepared by anodizing a silver wire, a silver electrodeposit, or a silver, silver oxide paste in a chloride solution. Another consists simply of a rod of antimony made by casting the metal in a pyrex tube and then exposing to air. For details of these two electrodes and others, reference should be made to a textbook on electrochemistry.

Potential Measuring Instruments

The sensitivity and accuracy desired governs the specific type of instrument needed. With some metal-solution systems very small currents, of the order of microamperes, suffice to change the metal potential appreciably (electrode polarization). In these cases the current needed to actuate the indicating mechanism must be less than the minimum current causing polarization to an extent greater than the required precision. Furthermore, the smaller the actuating current the smaller are the IR drops in the circuit and the less the need for corrections to the measured potential.

It should not be concluded from the above that the more sensitive an instrument is the better it is suited to any purpose. An overly sensitive instrument is unsatisfactory if for no other reason than inconvenience. Corrosion potentials are not equilibrium values and indeed often are not very steady even after prolonged periods. Thus, an instrument capable of measuring to a millivolt can do little but cause confusion with a cell that fluctuates as much as 10 mv about a mean value.

The discussion below pertains only to the principles of three types of DC instruments and does not include any information on the wide variety of field and laboratory voltage and current measuring devices now available.

Moving Coil Voltmeter. This instrument is essentially a galvanometer in which the scale is calibrated in volts. It consists of a coil of wire or metal strip both ends of which terminate at the instrument's binding posts, a pointer mounted along a diameter of the coil, a permanent magnet and an appropriate scale. The coil plus pointer is mounted between the magnet poles in such a way as to permit free movement only in the plane of the coil. When current is tapped off the circuit, it flows through the coil, and interaction with the magnetic field causes the coil to deflect. The degree to which this occurs depends on the current, which is determined by the available voltage and the coil resistance.

Because it is undesirable to draw current from a cell whose potential is being measured, the higher the voltmeter resistance the better. However, this is limited by considerations such as overcoming bearing resistance and providing linear response. A good voltmeter of this type usually has a resistance of

20,000 ohms per volt. It is clear that appreciable currents may be drawn even so and it is for this reason that other voltage measuring devices usually are used in electrochemical measurements.

Vacuum Tube Voltmeter. The inherent current-drawing disadvantage of a voltmeter can be overcome in large part by combining it with a vacuum tube circuit. In the simplest case the potential to be measured is applied to the grid of a triode. In essence the negative bias on the grid is adjusted so that there is no plate current when there is no applied potential. The unknown cell is put in the circuit so that the positive end feeds into the grid and the negative end to the filament. When the unknown potential is introduced, it upsets the adjustment and plate current flows through the meter circuit, causing deflection of the needle. The greater the potential the greater should be the plate current and this relation should be linear. The measuring circuit therefore draws only negligible current from the cell under study in comparison with the moving coil voltmeter.

Linearity and greater sensitivity and accuracy require more complex circuits which are not described here. Many such circuits have been developed, however, and are in common use. One convenience worth mentioning is the use of a meter with a center zero to permit following changes through polarity reversal with minimum difficulty.

The Potentiometer. This comprises a circuit in which the unknown potential is measured by comparing it directly to one whose value is known or is readily determinable by a simple arithmetical operation. A working cell capable of providing steady voltage for a reasonable time even under conditions involving small current drain is connected through a variable resistance to both ends of a length of uniform resistance wire. Thus, any potential from zero up to the maximum obtainable from the cell is impressed across the full length of the wire. The potential drop across any portion of the wire is calculable from the ratio of impressed potential to wire length multiplied by the length of the portion in question.

In order to know the potential drop per unit length of wire, the wire is calibrated using a standard cell. This is a cell which provides an accurately known, re-

producible potential. Some form of a cadmium-amalgam, cadmium sulfate, mercurous sulfate, mercury cell is used.* This is connected to the same uniform wire, on one side via a post shared in common with the lead from the electrode of the same sign of the working cell and on the other through a sliding contact. A galvanometer in series, usually between the sliding contact and the standard cell, is used as a null indicator. If the sliding contact is set at some arbitrarily chosen point, the variable resistance in the opposing circuit can be adjusted until the galvanometer shows zero deflection. When this is the case, the working cell has been adjusted so that the potential drop per unit length of wire equals the standard cell potential divided by the wire length between the standard cell contacts.

To determine the unknown potential, the standard cell is replaced by the cell in question and the opposing circuits are again balanced, but this time by moving the sliding contact until there is no deflection in the galvanometer. The unknown potential then is the product of the unit potential drop determined as above and the length of wire between the unknown cell contacts on the slide wire. In the actual case the unknown and cell and the standard cell can be switched back and forth into the circuit and the calibration checked as often as desired.

Potentiometers are no better than the uniformity of the slide wire used. The sensitivity is determined largely by the galvanometer used, the accuracy of the data depends on the quality of the standard cell and the reproducibility with time rests to a large extent on the quality of the working cell. The characteristics of each of these components is determined by the specific experimental requirements. There are many additional ramifications and conflicting effects but for corrosion potential measurements highly specialized components are not needed unless cells of very high internal resistance are to be measured. In this case it is generally best to use a vacuum tube potentiometer, an instrument which in its simplest form works much like the vacuum tube voltmeter described above. Such instruments are useful also in polarization experiments in which only small current densities cause extensive polarization.

*Weston cell; Epply cell.

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An Educational Lecture

The Use of Organic Protective Coatings In Controlling Corrosion *

By EDWARD G. BOBALEK

Introduction

THE MOST ANCIENT, the most popular and a more or less successful method of controlling corrosion is through the use of a film of paint. Organic coatings are of course not the only kinds of coatings. For example, the usefulness of metallic coatings, with oxide or other types of inorganic films that are controlled by alloying or chemical treatment and ceramic films bonded to metal are familiar. By comparison, however, with paint, the volume of inorganic protective coatings used is relatively small. Certainly, inorganic films, whatever be their future promise cannot be fitted as versatily as organics to the great variety of protective problems.

Coatings are very complex and as a rule only partly organic in composition. An indefinite number of different types of paint can be made by using one or several substances selected from literally many thousands of commercially available raw materials. The design of specific types of coating is in the hands of technologists who are both artists and scientists, and who, in the language of the paint trade, are called *formulators*. Formulators have designed thousands of different kinds of coating compositions, which taken all together, have a market value of about \$1,500,000,000 per year. Probably more than three-fourths of the great multitude of useful paint formulas are attempts to solve at least in part the metal protection problem.

The most useful classification of coatings is not one based on composition. Classifications should be made according to the special types of corrosion problems which motivate the formulator, for example, as in automotive finishes, marine finishes, underground pipe coatings, aircraft finishes, etc. While for any protection problem certain types or compositions of paint may have a temporary dominance for one reason or another, it may be possible to use equally well any of an enormous variety of paints that differ very radically in composition. Practical examples of the manner in which certain compositions have solved certain protection problems will be examined.

Fortunately, there is no need to review coatings solely in terms of specific examples. A careful analysis of the paint art will show that while it is very confusing in terms of specific details, it can be described also in terms of a relatively few general principles. Most engineers, sometimes for good reasons, have an antipathy for general principles. However, a certain amount of theory or philosophy is essential for even

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Abstract

The principles applying to the formulation of organic coatings are given and the effects of vehicle, pigments, and thinners are discussed. Special problems applicable to the preparation and application of plastic coatings are discussed with particular reference to their adhesion, solubility, and pigment dispersion characteristics. Plastic prefabricated liners, liquid coatings, dispersion resins, hot melt techniques and mastics are covered. The mechanism by which coatings retard corrosion are listed and the relative value of barrier and polarizing coatings mentioned. Coatings suitable for severely corrosive environments are considered and the special qualities of coatings suitable for use underground are listed. The questions of adhesion, permeability, surface preparation and chemical stability are correlated for coatings suitable for underground pipe or marine vessels.

the most practical of engineering conclusions. So consider first a minimum of theory in a general way—then by a few examples see how such general theory affects practical conclusions of a specific nature.

Composition of Organic Coatings

All coatings contain a resinous or resin-forming constituent called the *binder*. This can be a liquid such as a drying oil, an oil-resin varnish, or resin syrup that can be converted to a solid gel by chemical reaction. In most instances, where the *binder* is either a solid or is too viscous to be applied as a fluid film, a volatile solvent or *thinner* is used also which evaporates after a liquid film is deposited. The evaporation of the thinner facilitates or causes solidification of the film. Most paints also contain *pigments*. These are insoluble solids of very fine particle size; that is, as small as 1/100 micron and usually no larger than one micron. The *binder* and the pigment make up the non-volatile or film-forming part of the liquid paint. The protective properties of a film are determined primarily by the choice of *binder*. In the old days of paint technology,

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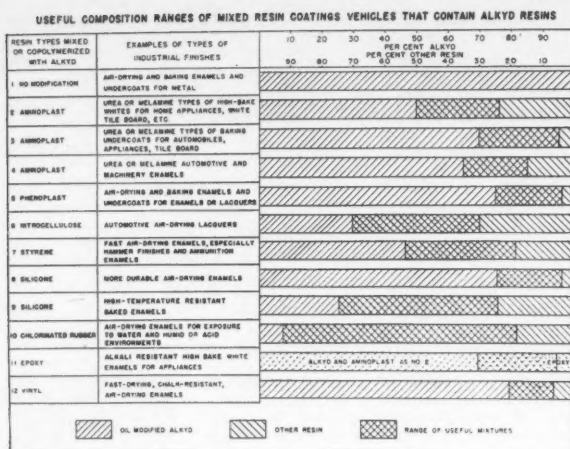


Figure 1

TABLE 1—Chronological Listing of Earliest Experimental Use of Synthetic Resins (Plastics) in Coatings

1910-19	Phenolic Resins	1938-43	Vinyl Resins (Acrylonitrile-Vinylidene Chloride) Nylon and Polyurethane Resins
1920-25	Alkyd Resins (Oil-Modified) Cellulose Nitrate and Acetate		Melamine Resins
1925-31	Vinyl Polymers (Chloride-Acetate) Acrylate Resins Cellulose Aceto-Butyrate Urea Resins		Allyl and Unsaturated Polyester Resins Cyclohexanone Resins
1932-37	Ethyl Cellulose Polystyrene Synthetic Rubber Vinyl Acetals	1943-51	Epoxy Resins Polyethylene Poly Fluoro (or Fluoro-Chloro) Ethylene Silicones

TABLE 2—Classification of Paint and Vehicles According to the More Important Resins Used as Binders

Class I—Systems Containing Alkyd Resins	Class II—Systems Containing No Drying Oil or Alkyd
A. Alkyd Resins, oil-modified 1. oxidizing (air-drying types) 2. non-oxidizing types B. Resin Mixtures containing alkyds 1. Two-component mixtures a. alkyds plus phenoplasts b. alkyds plus aminoplasts c. alkyds plus nitrocellulose d. alkyds plus chlorinated rubber 2. Three-component mixtures a. alkyds plus epichlorohydrin resin plus aminoplasts b. alkyd plus vinyl resins plus aminoplasts C. Alkyds modified by chemical reaction with other resins 1. styrenated alkyds 2. silicone alkyds	A. Curing (or thermosetting) types 1. phenoplasts 2. epichlorohydrin resins 3. allyl and other polyester resins 4. silicone resins 5. aminoplasts B. Non-curing (or thermoplastic) types 1. resins derived from cellulose 2. synthetic and natural rubber types 3. vinyl resin types 4. acrylic resins 5. nylon

the protective binders of possible usefulness were limited to materials such as drying oils, oil-natural resin blends, called *varnishes*, and pitches of the asphalt type. These materials have been known for several hundred years and they still find extensive use today.

However, the chemical and plastics industry of the past 30 years has supplied a large number of *synthetic binders* which make possible paints of better protective and decorative properties. At least several hundred

synthetic binders are available commercially. In general, however, each can be classified into a simple family or hybrid class of two or more simple types. Table 1 lists such a classification together with the approximate dates of their first use in protective paints. Practical paints are made of binders which are a complex mixture of two or more different resin types. By such manipulation of resin combinations, the formulator can design binders that are most useful for a particular protection problem. Tables 1 and 2 and Figure 1 illustrate some of the more common types of paints that use the newer synthetic resins.

Naturally, this complication of binder formulation serves to complicate formulation of thinners in paint compositions. There are very few, if any, solvents that are universal thinners for all resins. When plastic or synthetic resin binders are used in varying combination, the types and proportions of thinners must be selected to produce a fluid paint that can be applied easily as a useful film. Modern paint formulation relies on the use of several hundred commercial solvents. This is a marked contrast with the old oil-varnish-asphalt days of paint making, when not more than three or four types of thinners were available.

Practical coatings must contain at least a *binder*. Modern coatings usually contain also a *thinner*. Frequently a *pigment* is needed also. The pigment phase is usually a mixture of solids of different *colors* and varying degrees of opacity or *hiding power*. It is an oversimplification to say that the function of the pigment is purely decorative. Frequently, loading of the liquid part of the paint with suspended pigment is necessary to produce in the paint the type of fluidity that allows successful paint application and film structure. The pigment also contributes toward making the dry film more adherent, more impermeable to water and sometimes it is the factor which determines the actual protective properties of the film for electrochemical or other reasons. Before taking up the subject of pigment values however, it may be important to suggest some important facts regarding the formulation problems involved in combining the liquid paint vehicle with the pigment.

A pigment is a fine powder having a great surface area. It is the nature of fine dispersions of finely divided solids to tend to reduce their area exposed to liquid to a minimum either by coalescence (crystal growth) or by aggregation. Thermodynamically, all dispersions of fine solids in a liquid are unstable. Hence eventually, any paint will separate into a sedimented solid and supernatant liquid—that is to say, it is no longer a paint and cannot serve its designed purpose as either a protective or decorative coating. Useful paints, however, deteriorate slowly; sometimes requiring several years, but sometimes only a few minutes. The rate of retrogression largely depends on the viscosity of the liquid and extent of chemical attraction of the liquid for the pigment surface (popularly called *wetting*). Hence paint stability depends greatly on the choice of pigments, binders and thinners. In general, old types of paint vehicles, oils, varnishes and asphalts, whatever other faults they possessed, had a capacity for forming very stable paints with many pigments. The newer

synthetic resins or plastics, while they have other virtues, in general tend to form less stable mixtures with pigments. In fact, the most chemically resistant of these new synthetic resins cannot be pigmented at all. This has some important practical implications.

First of all, corrosion inhibiting coatings have been studied independently with respect to either the development of better protective pigments or better binders. Hence, as each direction of inquiry progressed the chance of combinations of the benefits of each research diminished. A great deal is known today about how to upgrade through use of pigments the old-fashioned types of vehicles and also how to make more chemically resistant binders. A combination of the two benefits, however, is still a problem of future research, and is called the dispersion problem. Until it is solved many benefits of research on new coatings cannot be used. Most practical coatings today require the use of both pigment and binder. This requires a choice of materials which does not realize in one package the theoretical possibilities disclosed by the independent directions of either pigment or vehicle research.

Even in instances of the more successful compromises, difficulties are introduced. Paint can change its properties slowly through aging or very rapidly when a non-specification tampering of the formula is indulged in. For example, choice of the improper thinner, or even too much of the right thinner can upset the dispersion balance to the detriment of both application and film properties. Therefore, the more protective and less stable paints based on synthetic materials need to be handled with much greater care than do old types if they are to perform according to design intentions. This discussion of formulation could be considerably amplified, but already one important conclusion is suggested, that is, progress toward better protective finishes is no easy road to be achieved solely by asking for the best results of all research in one package. Where the corrosion problem cannot be solved with old materials, one of the many new types can be used. However, by so doing there are introduced burdens and troubles of formulation and application that make all troubles with the old types seem by comparison to be almost serene.

Application of Organic Coatings

Organic coatings can be applied as:

1. **Prefabricated Liners.** These are sheets of rubber or plastic material that are laid over metal and glued in place either by heating the sheet to at least partial fluidity or by an adhesive. Except for unusual applications such as tape wound over a pipe, most applications of this sort are done with special equipment in a shop. The films can be so thick it is difficult to say whether the object is to protect metal or whether a plastic container is supported by metal. Equipment for handling corrosive chemicals frequently is made in this manner. Tapes also have some interesting and only partly explored possibilities, especially for exterior pipe protection. Particularly as new and better adhesives are developed, this can become in time an application method the importance of which can hardly be realized today.

2. **Liquid Coatings.** These products are applied by the traditional paint application methods: Spray, dip, roller coating, tumbling, brushing, etc., followed by a process for a removal of the volatile thinner and/or curing the film. Probably more than 95 percent of organic coatings for products finishing are applied in this way. For many of the more modern synthetic resin paints—principally the non-heat-curing (thermoplastic) types—this method of application has serious limitations; namely, the most chemically resistant and possibly most protective binders are solids that cannot be dissolved and are not readily used in paints. Efforts to bring the advantages of liquid paint application to these superior plastics has favored extensive research on two application techniques not yet in wide commercial use but which deserve mention because of their future promise.

a. *Dispersion Resins.* Tiny spheres of the resin (usually 10 microns or less in size) are suspended in a volatile carrier liquid in which they are insoluble. This may be water or an organic liquid. The insoluble resin particles are suspended in the same manner as the pigment. The entire paint vehicle (liquid part of the paint) is volatile. When the vehicle evaporates the mixture of pigment and resin particles is left behind and film formation is completed by baking for a short time to fuse resin particles into a continuous film. Sometimes the resin particles are sufficiently tacky so that when crowded together they coalesce slowly into a continuous film even at room temperature. These are the liquid paint application techniques that use emulsions or organosols.

b. *Hot Melt Techniques.* Many resins that cannot be dissolved in thinners can be melted and then applied. The film is fixed by solidification on the metal surface. Dipping or roller coating and sometimes spraying are useful application techniques. An interesting variation is flame spraying. Here the powdered resin, or mixture of pigment and resin powder, is blown through a special spray gun where the nozzle is surrounded by a hot flame which melts the resin. The resin solidifies as a coherent but not entirely continuous film on the work being coated.

While these new methods of applying resins of better corrosion resistance are good they have limited use for reasons other than impracticality of technique. It will be shown later that solving the engineering problems of applying the better synthetic resins as liquid films does not result automatically in coatings of superior protective properties.

c. *Mastics.* Mastics are liquid coatings which differ from the conventional type only in that they are very viscous and hence can be applied by troweling, high pressure spraying and by other techniques used for familiar materials such as caulks and putties.

Very thick films can be applied, sometimes in excess of 20-30 mils in one or two coats. The newer synthetic resin mastics can be based on either thermoplastic resins or thermosetting resins and usually film formation is completed by evaporation of volatiles and/or

curing reactions at room temperatures. Baking can be used if it does not render the composition so fluid that it sags. This technique has been neglected for too many years and even today only a few coatings manufacturers offer such products. However, this very logical method of coatings application is bound to grow more popular. It allows the use of some of the most chemically resistant resins at film thicknesses that compete with prefabricated plastic liners. Mastics would be particularly useful in field applications or for maintenance of metal structures. The same purpose might be served by ordinary liquid paints except that too many coats might be required to get films that yield adequate protection. The importance of film thickness is discussed very thoroughly by Tator.¹

How Coatings Retard Corrosion

The title of this portion of the discussion is very ambitious. It is known that coatings protect and in a general way something is known about the factors that affect the protective qualities. In particular instances, however, it is difficult to weigh the relative importance of different factors so as to define a simple mechanism for the protective function. In spite of the imperfections of knowledge, it is true that some considerations are especially important and can be isolated with sufficient accuracy to rate their influence on decisions relating to design and use of coatings.

It is understood in general that there are anodic and cathodic areas on a metal surface, which together with water, electrolytes and oxygen constitute more or less efficient galvanic cells. The greater the current flow through the cells, that is, the greater the potential difference and the less the resistance, the more rapid the corrosion process. Corrosion can be retarded by increasing the resistance of the electrolyte or by decreasing the potential difference between electrodes of opposite polarity, or both. Note that decreasing the electrolyte concentration or passivating or polarizing the electrodes retards the corrosion rate. If coatings are to help control corrosion, they must affect the electrolysis reaction according to some of the ways indicated.

With reference to the electrochemical mechanism of corrosion, the effect of organic coatings can be classified as follows:

I. Coatings That Function Primarily as Barriers.

These exclude from or retard diffusion of water, electrolytes or oxygen to the electrolysis area.

Efficiency in this respect depends on the film having a very low permeability to corrosion-promoting chemicals in the environment. In general, such coatings have very great resistance to chemical deterioration. Films most efficient in this include those containing synthetic resins such as polyethylene, polytetrafluoroethylene, some synthetic elastomers, vinyl polymers and fully cured thermosetting resins of certain classes such as the phenolics, furanes, and epoxy types. This group of film formers is represented by examples in the second column of Table 2.

II. Coatings That Assist Polarization Phenomena.

Many coatings of this class have rather inferior

resistance to chemical deterioration and are relatively permeable to water, electrolytes and oxygen. However, the organic constituents of the film are tightly held to the metal surface by van der Waal or weak chemical bonds and render the surface hydrophobic; that is, they exclude water and water-dissolved electrolytes not because of their impermeability, but rather by making the corrosion interface less wettable. Sometimes pigments in such films buffer the pH at a high value or they form reaction products (usually soaps) with constituents of the film forming binder which tend to be adsorbed on the metal surface and hence render it less wettable by water. Some pigments affect the oxidation-reduction reactions at electrodes and promote the formation of more tightly adherent and impermeable oxide films. Although this issue is still in dispute, many believe some pigments can act as sacrificial anodes and provide a sort of cathodic protection for the metal surface.

In short, Class II coatings (see Table 2) affect corrosion in many ways that modify the electrolysis reaction. Class I, or the barrier type, function mostly because they screen out more completely the corrosive environment. The ideal coating, of course, would be one that combines the best features of both classes. Unfortunately, this ideal is very difficult to reach for the following reasons:

The beneficial effects of Class II can be realized fully only if the coating has:

1. A considerable chemical attraction for the nearly always present oxide film on metal surfaces, and/or
2. Capacity to support in fine dispersion the protective pigments that beneficially affect electrode polarization.

A properly balanced film of this sort must have some polarity and in general is susceptible to chemical deterioration. Temporary protective action is excellent but eventually it is lost because the film deteriorates chemically and is removed from the metal surface by dissolution. If this dissolution occurs in a spotty fashion—say over an anodic area—and if the surrounding film deteriorates less to cause isolation of the small anodic area—then a deep pit can form very rapidly. Where one starts with a continuous film of the adherent type, pit corrosion occurs because of this spotty nature of chemical decay of the film. If the film is such that it decays uniformly then it is usually the kind which has a rather short service life, but then the corrosion is more uniform. Practically speaking, coatings of this type must be renewed frequently, either to forestall over-all corrosion in the case of the evenly and fast deteriorating types, or to prevent pit formation with longer lasting types which usually begin to fail in a spotty manner. The effectiveness of coatings of this type can be altered in a sensational manner by using the proper pigments, which seem to have anti-corrosive properties during the period of chemical deterioration of the organic part of the film.

Barrier types of films are not as likely to suffer either over-all or spotty deterioration. However, their chemical structure is such that they have inferior attraction (poor adherence) to the surface and they are poor media for dispersing or promoting the pro-

tective functions of anti-corrosive pigments. It is very important that such films be free of mechanical faults such as scratches or pinholes. The application of flaw-free and undamaged coatings is very difficult even in very thick films. These barrier films must in effect provide a leak-free envelope around the protected area. A leak will allow corrosion promoting chemicals to migrate under the film to produce creep corrosion that dislodges the film in blisters or large patches, leaving the metal unprotected.

Because of these considerations, two approaches are open in the search for a good protective film, both being different viewpoints in the direction of compromise; namely,

1. Upgrade the resistance to chemical deterioration of Class II coatings without sacrificing too much of their adhesion and efficacy with respect to optimum chemical interference with the early stages of the corrosion reaction, and
2. Upgrade the adhesion characteristics of the Class I barrier types without degrading too much their resistance to chemical deterioration.

Both viewpoints are represented in the use of the resin mixtures illustrated in Figure 1.

It is easy to overdo either angle of approach. There is no one ideal coating for all corrosion problems. Since each corrosion problem is different, it is likely that the best choices of coatings for diverse problems will be different. Theoretically this point is hard to clarify. However, in order to gain a better notion of this critical dilemma examine some concrete examples of particular protection problems and note the reasons for some choices made. Making such choices is one of the most important functions of the corrosion engineer because the proper decision requires full comprehension of both the corrosion problem and of the economics of its solution. One cannot make a good choice, except accidentally, if he understands only the rudiments of coatings theory out of context of the entire engineering problem.

Corrosion Problems and Specialized Protective Coatings

Coating of Containers for Strong Acids, Alkalies, Plating Baths, etc.

For this application no coating in the category of Class I is suitable. The conditions for chemical deterioration are so severe that no organic film containing saponifiable material can be tolerated. This excludes anything containing drying oil, alkyd resins, most phenolic resins and most vinyl and other thermoplastic resins that contain saponifiable plasticizer. The only recourse here is to use certain resins like synthetic elastomers (e.g. neoprene), or polyethylene, polytetrafluoroethylene or other plastics that have substantially no chemical reaction except possibly thermal degradation. These materials are ordinarily applied as prefabricated liners, using adhesives, by flame spray, as mastics or by other techniques that can build up very thick, relatively flaw-free films. Spark testers or other electrical resistance measurements must scan every inch for possible flaws or leaks, which must be repaired. In such instances, the metal may be regarded as a structural support for the plastic. To get proper support against mechanical

damage, the metal surface often needs to be roughened by a precise sandblasting operation. Even if the cost of surface preparation is disregarded, these liner coatings are very costly with respect to both materials and application. Their use is justified only in cases of extreme necessity.

Although liners may seem to be the ultimate in protection, they have serious weaknesses. The slightest mechanical damage puncturing the film is very serious. This includes damage done by sudden temperature changes where the difference of contraction or expansion of plastic and metal can cause the bond between metal and plastic to rupture or cause the plastic to crack. Many of even the more durable plastics will crack when embrittled by age. Mechanical damage even to thick films is easy and protection is lost thereby. Difficulties with this sort of combination metal-plastics system has greatly stimulated research toward use of chemically resistant plastics as structural materials. The cost of effectively protecting metal in very severe conditions sometimes can be more costly than even very expensive fabrications of plastic parts. Protection of metal with plastic liners is most feasible when frequent inspection is possible and parts on which the coating is damaged can be replaced easily, e.g., plating baths, temporary containers, etc. Protection is much more difficult where permanent structures are involved, e.g., tanks or equipment in a continuous chemical process.

Coatings for Underground Pipe

The most comprehensive data regarding the corrosivity of soils are included in the National Bureau of Standards Circular C-450. The factors emphasized can be listed in the following order of importance:

1. Differential aeration (caused usually by unequal compactness of backfill, the unequal porosity of the soil at different points, uneven distribution of moisture and restriction of air and moisture movement in the soil by buildings, roadways, pavements and vegetation).
2. Acid and salts in the soil (as shown by pH, total acidity and resistivity measurements).
3. Foreign materials in backfill at different points of contact (such as scrap metals and cinders which are cathodic to the pipe).
4. Interconnection of dissimilar metals.
5. Anaerobic bacteria (their life processes can depolarize cathode areas).
6. Stray electrical currents (such as may originate from electrical generators).

In varying degrees of importance, these same factors influence corrosion in any environment, for example, in corrosion of a steam return line in a flooded conduit. However, underground conditions generally are more variable than those in some fixed environment such as fresh or salt water and hence less predictable. For short periods soil can become extremely corrosive, even to metals such as stainless steel, while during longer intermediate periods it can be mild. Hence, average values on corrosivity, such as are represented by measuring metal losses over long periods of time, are of little significance. The most important question is whether corrosive conditions can develop, even though for short periods, which can lead to sufficient corrosion to puncture the pipe

where coating failures occur over very small areas. Most research on underground corrosion indicates a high probability that this can happen. Over a long period, the average soil corrosivity is low when compared, for example, to that prevailing in an acid storage tank or in marine immersion. However, for short periods unusually damaging electrolytic conditions can develop (differential aeration, differential drainage which sets up electrolyte concentration cells). Sometimes unusual conditions like acid drainage from stored coal, cinder fill or mine water, or stray electrical currents in the soil can set up short term conditions of great severity. This factor changes the point of emphasis of the protection problem. Instead of providing protection for metal in continuous and severe exposure for relatively short periods (i.e., ranging from a few months to five years), emphasis is placed on manufacturing stand-by protection during exposures which on the average are not severe, but which can become so at any time during ten years or more. The same problem exists if the remedy is cathodic protection, where the answer is not adequate capacity for average conditions, but rather maintenance of reserve capacity for the short severe periods, even if they occur infrequently. The short term protective qualities of a coating in very strong acids or alkalis is less important than its retention of mechanical continuity for very long periods, with respect to adhesion and the absence of flaws. Many of the better chemically resistant coatings are not distinguished for their mechanical permanence, when subjected to lengthy cyclic mechanical or thermal stresses.

National Bureau of Standards data on protective qualities of more than 200 of the older types of coatings show that virtually none were completely effective in preventing pit formation in even what were considered to be mildly corrosive soils. The coatings tested for long periods were for the most part bitumen types although plastic and oil-varnish types were well represented.* In all instances, protective efficiency deteriorates with increasing time of exposure. This author's analysis of the data would suggest the following conclusions:

1. No coating, even the most resistant plastic, is completely impermeable to water or electrolytes. For the less permeable coatings, the original higher degree of protection comes from adherence qualities that screen or help polarize electrode areas. Less adherent coatings are protective because originally they impede passage of water and electrolytes.
2. With time, the more adherent coatings deteriorate because of chemical attack on the coating. Deterioration starts in a spotty fashion conducive to severe pitting because small anodic areas are isolated by the tightly adherent surrounding coating. Creep corrosion may be limited at the start but pitting can be severe.

The more chemically resistant coatings materials tend to have poor adhesion. Flaws that develop from mechanical damage, e.g., abrasion or blistering, admit the corrosive medium which migrates freely to cause creep corrosion under the film which eventually lifts it in large patches. While the coating material itself has not deteriorated chemically, it no longer is protecting the metal and even mildly corrosive conditions can result in

punctures in unprotected areas which usually are larger than pits. This latter fault is, for example, shown commonly in the failures of some bituminous coatings and of some oil-free synthetic resin coatings. Failure by formation of small deep pits is more characteristic of some oil-varnish types.

It is impossible to draw a line that separates practical coatings sharply into classes which can be labeled chemically resistant and chemically non-resistant, or into very adherent or non-adherent. In general, however, test data tend to show that in the early stages of corrosion damage, pitting is more severe if exposed small areas are definitely isolated by good adherence of coatings to surrounding metal, whereas general creep corrosion over wide areas is more prevalent where adhesion is poor around imperfections in the coating. In the former instance serious damage is more immediate. While in the latter instance it takes longer, nevertheless the time required to produce serious damage is still far shorter than the expected service life of the coating. For coatings that adhere very well, original film faults are produced by spotty chemical deterioration; for the more durable plastics or bitumens the original faults may be the result of blistering or mechanical damage.

Summarizing the foregoing discussion and giving an opinion on the best compromise coating for long term protection of underground pipe, a suitable coating should have:

1. At least fair adhesion (this implies a more polar chemical structure, along with its consequence such as some susceptibility to chemical deterioration and less dielectric strength) but
2. This same coating must be hard and tough enough to resist mechanical damage and adherent enough to resist blistering. To the extent that chemical deterioration occurs in soil waters, the deterioration should be uniform. That is, there should be no tendency for preferential rotting out of small isolated areas in the film at which pit corrosion can occur.

Coatings good for underground pipe might not be useful in either in deionized water (where blistering occurs more readily than in soil waters) or in strong alkali (where spot chemical deterioration is more certain). The emphasis here is not maximum chemical resistance for unusual conditions but rather long term reserve protection underground, and here, beyond a certain minimum, chemical resistance is less important than is the mode of coating failure, its mechanical properties, and its adherence.

The erroneous assumption prevails that coatings which give the very best of protection in short term severe exposure (say in strong acids) should be even better in the milder soil exposures. The attractive simplicity of this assumption may have turned attention away from the fundamental issues involved in seeking the best coating for underground protection of metal. No research data are yet available which make possible precise engineering design of a coating for underground use and the above remarks represent only the conclusions this reviewer deduces from an analysis of a wide variety of data. This conclusion is actually the hypothesis which should guide future experimental work on underground coatings.

Insofar as corrosion of utility lines within under-

* Refer to pages 146-181, National Bureau of Standards Circular C-450.

ground conduits is concerned, the same conclusions apply. Although the corrosive environment immediately about pipe may be different, it still can be classified as comparable to that of the exterior soil. The main difference is that greater importance need be attached to the effects of deionized water in promoting coating faults by blistering. Moisture condensation caused by temperature variations above and below the dew point can provide frequent exposure of the pipe coatings to a condensed film of deionized water which accelerates failures by blistering.

A great variety of coatings have been tried for pipe protection underground, for example:

1. **Bituminous Coatings**, supported or unsupported, with or without rubber, plastic or fabric wrapper.

Because such coatings generally have poor adherence great emphasis is placed on making the coating sufficiently thick and fault-free to exclude the corrosive medium. Even with a fault-free coating, success is only moderate. Resistance to osmotic transmission of water and electrolyte is only fair and the long term decomposition products of such coatings can themselves be corrosive, particularly if much water accumulates at the coating metal interface. Mechanical damage can occur easily during shipment and usually touch up and repairs in the field do not restore damaged areas to original condition. Exposure to extremes of low temperature prior to or after installation tends to embrittle the film and make it more susceptible to cracking or mechanical damage by soil movement or freezing stresses in surrounding water. Long term protection with bituminous pipe coatings is most successful in climates where temperature changes are not extreme, where the nature of the soil is such that expansions and contractions do not vary widely with moisture content and where extremely corrosive conditions (such as seepage of acid mine water) do not occur. Rubber or plastic wrappers over pitch coatings are beneficial in acid mine waters but these extra costly features help very little if the possibility of mechanical damage is great.

2. **Thermoplastic Coatings**. In their original undamaged condition, vinyls and other thermoplastic coatings exhibit superior protective properties because their toughness and abrasion resistance are excellent. Like the bituminous coatings, however, their adherence is poor, hence corrosion which starts at flaws can spread beneath an apparently intact film. However, the better plastics have greater impermeability to water and to other corrosives than has asphalt; hence, except for the occurrence of film flaws, the coating is more protective. Nevertheless, there are other serious deficiencies. For the better thermoplastic resin coatings, both raw material and application costs are high. An even more serious difficulty is inherent in the chemical nature of most thermoplastic films, nearly all being effective only when modified with a considerable quantity of a less permanent plasticizer. The choice of kind and proportions of plasticizer is a critical feature of the formulation. The plasticizer is more readily deteriorated by chemicals than is the resin and even when

its chemical resistance is great, it may be squeezed from the film by high soil pressures or lost by vaporization at moderate or high temperatures or leached out by water or other solvents. Even small disturbances in the resin-plasticizer balance affect unfavorably the protective properties of the films, particularly because they make the film more susceptible to mechanical damage and/or adherence loss. For example, arctic underground conditions are ideal for promoting deterioration of thermoplastic films. This characteristic makes it necessary to reject for arctic use all but a very few of the many thermoplastic resin formulations that contain plasticizers.

Some thermoplastic systems do not require plasticizers in addition to what is supplied by the lower molecular weight portion of the resin composition. This is particularly true, for example, for some of the synthetic elastomers such as Thiokol and acrylonitrile or butyl rubbers. Perhaps some of the modified polyethylenes and certain fluorinated polymers also can be included in this group. Some of these compositions can be vulcanized or used in conjunction with reactive phenolic resins and hence are not strictly thermoplastic types. These materials have not been used extensively for coatings so very little is yet known regarding their practical worth in long-term underground exposure.

Cold setting mastics are of particular interest. Some compositions of this class are commercially available, but there has been insufficient time to establish an impartial evaluation of their value and their economics. It is doubtful that thermoplastic mastics will remain effective over continuously hot surfaces. However, at moderate and very low temperatures at least some should have excellent resistance to both chemical deterioration and mechanical damage.

3. **Thermosetting Resin Coatings**. It is a popular though inaccurate custom to refer to all coatings of this class as phenolics. As pointed out earlier herein, a wide variety of resins and resin combination can be used in these coatings. Most require high temperature baking, but some can be cured catalytically at low temperatures.

Properly applied, these coatings offer about the best compromise among mechanical stability, good chemical resistance and satisfactory adherence. Of particular interest is their thermal stability. This feature is best illustrated by results of extensive tests on phenolic moldings and laminates. In general, for phenolic resins in short term exposure, tensile and flexural properties do not vary from their 77 degree F values by more than about 15 percent over the temperature range of -60 to +150 degrees F. They show little change in impact resistance down to at least -80 degrees F. No data are known which are specific for phenolic paint films, but at least general conclusions of other studies will apply here and have in fact been confirmed by service performance of phenolic coatings and laminates.

Because of their thermal stability, phenolic and other similar coatings should be resistant to embrit-

tlement cracking, flaking and mechanical damage even at low temperatures. This has been confirmed by experience with some formulations, particularly on aircraft. This property is not peculiar to phenolic coatings but is general for nearly all highly cured thermosetting resins, including the allyl coatings which chemically do not resemble the phenolics at all.

The disturbing factor insofar as coatings on metal is concerned, however, is the fact that their physical stability is very dependent on an optimum and adequate degree of cure. That is, the proportion of uncured residue (always present in some proportion in any cured thermosetting coating) must be small. As the quantity of this uncured part of the resin composition is decreased, usually the adherence of the film is proportionately less. This means that if a film is cured sufficiently to be very stable mechanically then its adherence may decrease and other troubles such as greater blistering tendencies may become significant. Should this be true, then the film is less protective than it would be if it had been cured to a lesser degree.

Hence, any protection problem requires a different compromise between the two possible directions of fault. The best compromise between contrary faults is different, for example, in aircraft as compared to what it would be for pipe protection in the arctic. The corrosive medium is less in the former instance and only enough adhesion and flexibility need be maintained to prevent stripping of film due to high speeds and very rapid fluctuations of temperature. The service life of the coating is short and replacement is easy.

Corrosion protection underground, on the other hand, puts a premium on adherence for much longer times. Coatings designed and applied to give long term adherence may withstand very well the relatively mild cycles of temperature change such as occur during continuous service even of pipe buried in permafrost soil. However, the limited cure required to preserve this good adhesion gives films that contract and expand more when exposed to more extreme temperature changes. Thus they would be more susceptible to damage during pre-installation shipment or storage in areas where cycles of extreme changes of temperature may occur and their adherence and protective value may be reduced seriously even before the pipe is buried into a more stable thermal environment.

The underground corrosion problem has been reviewed because it illustrates so well some of the complexities involved in choosing a good coating and shows the economic consequences of striving for the best in terms of very long protection under relatively mild corrosion conditions. Many times, however, the problem is simplified by circumstances. For example, a very simplifying circumstance would be a case in which the corrosive environment is constant, temperature is not very variable and inspection and repair are relatively easy. Such a situation prevails approximately in 3 below.

3. Marine Finishes. Possibly more research has been done on ship bottom paints than on any other type of coating. Some very specific answers have been found in terms of both the old style finishes and also in terms of new plastic materials.

In ship bottom paints two functions are essential: 1) corrosion inhibition and 2) retardation of the growth of marine organisms which, in addition to creating other problems, help deteriorate the film and otherwise assist the corrosion process. A long time ago standards were established for ship bottom paints which call for the use of two types of films—an anti-corrosive primer and an anti-fouling top coat. The primer should be as impermeable as possible while still allowing good adhesion and proper use of anti-corrosive pigments, both being major determinants of the success of a primer. The top coat must not be too stable and is loaded with pigments having anti-fouling properties. It is important that this anti-fouling top coat shall deteriorate evenly to expose fresh layers of active anti-fouling pigment at a rate sufficient to be poisonous to marine growths. These features are common to marine systems of either the old type or of the new plastic types.

Old type marine primers used a binder definitely of the adherent Class II type referred to earlier. This contains as a film former about 70-75 percent of linseed and/or chinawood oil, both known for adherence and pigment supporting properties. The remainder of the composition is made up of a less saponifiable phenolic resin which makes the film water resistant and more permanent, but the use of which does not reduce too much the adherence and pigment supporting properties of the oil. This composition of oil and phenolic resin is a varnish type vehicle. When applied under ideal conditions, such a varnish binder may function protectively for several months to more than a year as compared to only a few weeks for the unmodified oil. The actual protective value of the primer depends a great deal on proper choice of pigments—the right blends of different types, e.g., lead pigments and chromates must be used in optimum dilution with the right sort of extender pigments which of themselves have no protective value, but which are important nevertheless in bringing about the proper effect of the active, anti-corrosive types. The anti-fouling top coat contains copper or mercurial types of pigments in a vehicle designed to leach away at an even rate. The top coat has virtually no protective properties except in protecting the primer from organisms.

For many years attempts have been made to use plastic types of binders for the primers on ships to increase service life. One of the more notably successful plastic binders are the vinyl resins. Ordinary vinyl resins have poor adherence to metal and are of the Class I or barrier type referred to earlier. Because adherence is poor, their use originally was not crowned with much success in actually coating ship bottoms. However, a partial solution was found to the problem which well may indicate what should be the trend of research in the use of other binders of

Class I. The solution to the problem involved the following:

- a. Development of a special metal treatment—this consisted of special chromate pigments, phosphoric acid and an alcohol soluble resin (polyvinylbutyral). This provides a film 0.1-0.3 mils thick over a moderately well cleaned metal surface and it can be dried at room temperature.
- b. Development of a new vinyl resin (a copolymer of vinyl chloride, vinyl acetate, vinyl alcohol) which although somewhat less resistant to chemical deterioration than some other vinyl resins, had the important property of adhering to the tightly bonded metal treatment. This new resin could be pigmented with red lead (an anti-corrosive pigment) and applied as a lacquer over the treated metal surface. (Film thickness should be high; for best results 4-10 mils).
- c. A vinyl resin to hold anti-fouling pigment was adjusted to deteriorate uniformly by chalking by compounding it with water-sensitive rosin. Such a binder, loaded with anti-fouling pigment was applied as a lacquer, again building up a heavy film thickness.

The new vinyl system has a service life at least three times as long as the old varnish type system so its use is worthwhile when its higher cost is outweighed by the advantages of reducing repainting frequency.

Apart from this achievement, however, it has been shown that in order to use the better binders, the adherence problem must be solved. The most likely way to accomplish this is through research to develop chemical treatments which produce an intermediate interface between inorganic metal and organic plastic.

While this principle is likely to be applied in the future to many other resins it has immediate practical value in this one example only.

References

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2. T. S. Carswell, et al. *Modern Plastics*, **19**, 65-69 (1942). See also T. S. Carswell, *Phenoplasts*, Interscience Press, New York (1947) p. 128ff.

PUBLICATIONS ON CORROSION

Remittances must accompany all orders for literature the aggregate cost of which is less than \$5. Orders of value greater than \$5 will be invoiced if requested.

● BOOKS

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Control of Pipe Line Corrosion by O. C. Mudd

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Report of the Correlating Committee on Cathodic Protection

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Publication 52-3
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NACE Committee Directory

Publication 53-2
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● TECHNICAL REPORTS

- TP-1 Report on Field Testing of 32 Alloys in the Flow Streams of Seven Condensate Wells (Pub. 50-3) NACE members, \$8; Non-members, \$10 per copy.
- TP-2 First Interim Report on Galvanic Anode Tests. (Pub. 50-2) NACE members, \$3; Non-members, \$5 per copy.
- TP-3 First Interim Report on Ground Anode Tests. (Pub. 50-1) NACE members, \$3; Non-members, \$5 per copy.
- TP-1D Sour Oil Well Corrosion. Corrosion August, 1952 issue. NACE members, \$5.00; Non-members \$1 per copy.
- TP-1G Field Experience With Cracking of High Strength Steel in Sour Gas and Oil Wells. (Included in Symposium on Sulfide Stress Corrosion. (Pub. 52-3) \$1 per copy, 5 or more copies to one address, \$5.00 per copy.
- TP-5A Materials of Construction for Handling Sulfuric Acid. Corrosion, August, 1951, issue. NACE members, \$5.00; Non-members, \$1 per copy.
- TP-5C Stress Corrosion Cracking in Alkaline Solutions. (Pub. 51-3) Per copy, \$5.00.
- TP-6G First Interim Report on Recommended Practices for Surface Preparation of Steel. (Pub. 50-5) Per copy, \$5.00.
- TP-6G Second Interim Report on Surface Preparation of Steels for Organic and Other Protective Coatings. (Pub. 53-1) Per copy, \$1; five or more copies to one address, per copy \$5.00.
- TP-12 Report on Electrical Grounding Practices. Per copy \$5.00.
- TP-19 Corrosive Effects of Deicing Salts—A Progress Report by Technical Practices Committee 19. Corrosion, January, 1954, issue. NACE members \$5.00; Non-members \$1 per copy.

● REPRINTS

- Cathodic Protection and Pipe Lines*
Mitigation of Corrosion on City Gas Distribution Systems by A. D. Simpson, Jr. .50
- Paints and Coatings*
Gasoline Resistant Tank Coatings by W. W. Cramer50
- Tests, Properties of Corrosion Preventive Lubricants for Lead Sheathed Cables in Underground Ducts—A Discussion by Howard S. Phelps and Frank Kahn.... .50
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- Why Metals Corrode by H. H. Uhlig50
- Corrosion Control by Magic—It's Wonderful by H. H. Uhlig50
- Index to Corrosion, Volume 850

REPRINT

Publication 53-1

Surface Preparation of Steels For Organic and Other Protective Coatings

- Second Interim Report of NACE Technical Practices Sub-Committee 6-G on Surface Preparation for Organic Coatings.

This report itemizes the various procedures used to prepare steels for the application of protective coatings. Recommendations as to procedures, standards, safety measures are given. This second report by NACE TP-6G is the culmination of many months of work by committee members. The report has been carefully prepared and checked by committee members with long experience in the coatings application field.

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- 1947—January, March, June, July, September, November
1948—January, February, May, June, July, August, December
1949—January, February, June, July, August, September, October
1950—January, February, April, May
1951—January, February, March, October
1952—March

Indices to Corrosion technical literature have been published as follows:

- 5-Year Index, 1945-49 inclusive and
Index to Vol. 6, 1950 December, 1950
Index to Vol. 7 December, 1951
Index to Vol. 8 December, 1952
Index to Vol. 9 December, 1953

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TEXAS



Topic of the Month

Organic Inhibitors Improve Ammonia Control, Reduce Sulfide in Refinery Waste Waters

By J. J. HUR*

ALKALINE waters bearing high concentrations of sulfides are one of the stumbling blocks in programs for modernization and expansion of waste disposal facilities at refineries but recently developed corrosion inhibitors appear to provide a means of simply and economically mitigating the problem.

Crude distillation units as shown in the typical flow diagram, Figure 1, are a principal source of the troublesome wastes. Large quantities of open steam are injected into the distillation column to aid in separating the various products or fractions shown. The steam and any water contained in the crude oil feed are concentrated in the overhead vapor from the tower, then condensed along with the naphtha in the overhead condenser and finally settled and decanted to waste disposal from the reflux drum.

Hydrogen sulfide and hydrogen chloride generally are released when the crude oil is heated in the furnace prior to entering the tower. These two acid gases also concentrate in the overhead system. The result is one of the major problems of the refinery corrosion engineers.

For years many refiners, including Atlantic, have used ammonia to neutralize the acids and obtain some measure of corrosion control. The ammonia normally was injected into the overhead system at point "A" in Figure 1. Sufficient quantities were injected to raise the inherent pH level (between 2 to 5) of the condensate water to 7.5 to 8.5 pH. Ammonia injection did not eliminate corrosion but reduced it to tolerable levels but as far as the waste control engineer was concerned, it aggravated his problem. The sulfide concentrations from absorption and dissolution of hydrogen sulfide in the condensate waters were increased 10 to 100-fold by the neutralization reaction.

In recent years numerous high molecular weight, semi-polar organic compounds have been developed and marketed as filming type corrosion inhibitors. Refiners have come to use these materials in crude

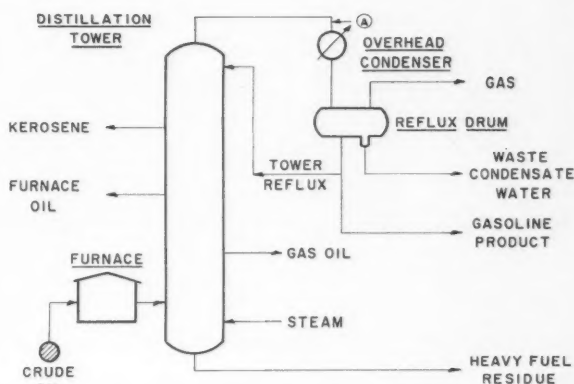


Figure 1

still overhead systems primarily to supplement ammonia control by introducing suitable solutions of the inhibitors into the system at or near the same location as the ammonia ("A" in Figure 1). In most instances the application has resulted in a substantial (80-95 percent reduction in corrosion, if the condensate water was maintained at near neutral pH levels with ammonia.

Some of the proprietary inhibitors have an added advantage in that they facilitate control of the problem attending disposal of sulfide waste waters. Field trials established that at double normal dosage rates of 1 quart per 1000 barrels of gross overhead flow, such inhibitors could satisfactorily control corrosion at pH levels as low as 3. This makes ammonia injection unnecessary (which counterbalances the additional inhibitor cost) and in turn reduces the sulfide content of the waste condensate waters to very low levels. Instead of being absorbed in the water and reacting with the ammonia, the hydrogen sulfide remains in the gas phase from which it can be conveniently recovered in subsequent refinery units and converted to sulfuric acid.

*Supervising Chemical Engineer, The Atlantic Refining Company, Philadelphia, Pa.



NACE News

Wachter, Whitney and Brannon to Head NACE



E. H. Dix, Jr.



Irving H. Denison

Scientists Distinguished for Corrosion Work Named to Receive Whitney and Speller Awards

Two scientists who have made significant contributions toward a better understanding of how corrosion may be controlled have been selected to receive the 1954 National Association of Corrosion Engineers' Awards. Dr. Irving A. Denison, best known among corrosion workers for his contributions on soil corrosion, will receive the Willis Rodney Whitney Award. E. H. Dix, Jr., whose work toward better understanding of corrosion processes in aluminum and magnesium alloys dates to 1919, will receive the Frank Newman Speller Award. The Whitney award is in recognition of contributions to corrosion science and the Speller Award in recognition of achievements in corrosion engineering.

They will be the eighth recipients of the awards, established and first presented by NACE in 1947 honoring the persons after whom they are named.

Presentation of the awards will be by M. G. Fontana, Ohio State University,

Columbus, immediate past-president of NACE and chairman of the awards committee. The presentation is at the NACE annual banquet, to be held on Wednesday, March 17 at Hotel Muehlebach, Kansas City.

Joined NBS in 1929

Dr. Denison joined National Bureau of Standards in 1929 after working as chemist in the laboratories of the Bureau of Soils, U. S. Department of Agriculture. During World War II he assisted in the development of special primary batteries for military use.

In 1946 he was assigned the responsibility of bringing to a conclusion the bureau's soil corrosion burial program and after completion of this task in 1953 he joined the staff of the Diamond Ordnance Fuze Laboratories, originally a part of the National Bureau of Stand-

(Continued on Page 3)

Payment of 1954 Membership Dues

In order to avoid interrupted mail and missed copies of CORROSION all NACE members who have not done so already are urged to remit their 1954 MEMBERSHIP DUES before March 31. Association by-laws require that the names of those whose dues are not received by March 31 be dropped from the membership mailing list.

T. P. May, Jack Harris, Harry R. Brough Are Elected Directors

Aaron Wachter, currently vice-president of the National Association of Corrosion Engineers, has been elected president; F. L. Whitney, Jr., Kansas City Conference Technical Program Chairman, vice-president and Russell A. Brannon, currently treasurer, has been reelected, all for the 1954-55 term beginning the last day of the Tenth Annual Conference at Kansas City. These results were certified by the tellers who counted secret ballots at Houston Central office of NACE January 9.

The tellers also certified to NACE President Walter F. Rogers the following as elected to directorships: T. P. May, representing active members; Jack W. Harris and Harry R. Brough for directors representing corporate members. All take office at the same time as national officers.

Mr. Wachter, who is with Shell Development Company, Emeryville, Cal., has a long record of activity in NACE, including work on technical committees, publication of technical papers and otherwise, specializes in corrosion investigations. Mr. Whitney, with Monsanto Chemical Co., St. Louis, formerly a director representing North Central Region, has long been active in association affairs.

Mr. Brannon, Humble Pipe Line Company, Houston, and a past president of NACE, will begin his third term as treasurer.

Mr. May, with the Corrosion Engineering Section, The International Nickel Co., Inc., New York, has served for many years on the NACE Editorial Review Subcommittee and has been its chairman during the past year. He is author of many technical articles published in CORROSION and has addressed many sectional and regional meetings of the association.

Mr. Harris, Beaumont Iron Works, Houston, was exhibits chairman for the NACE's Galveston Conference. Mr. Brough, Mountain Fuel Supply Co., Salt Lake City, Utah, is chairman of the Salt Lake Section.

More than 2260 ballots were counted.

Kirkbride Elected

Chalmer G. Kirkbride, president and director of Houdry Process Corp., Philadelphia has been elected president of the American Institute of Chemical Engineers for 1954. Barnett F. Dodge, professor of chemical engineering and head of the Yale University Chemical Engineering Department has been elected vice-president.

Larrabee Is Named Vice-Chairman of NACE Technical Practices Group

C. P. Larrabee, United States Steel Corp., Vanderdrift, Pa., a member of the National Association of Corrosion Engineers' board of directors representing corporate membership has been named vice-chairman of the Technical Practices Committee. Mr. Larrabee also has been active in NACE in capacities other than that of director and has contributed technical material for publication in the association's official journal, *CORROSION*.

A chemical engineering graduate of the University of Maine, he has been with the Research and Development Laboratory of United States Steel since he completed 10 years' work at the National Bureau of Standards. Since 1935 he has been in charge of the laboratory and field corrosion testing work on structural, low alloy and stainless steels.

Canadian Regional Meeting Set February 12

The NACE Canadian Regional Division will hold a meeting February 12 in Toronto, Ontario, Canada. R. J. Law, director of the Canadian Region, H. P. Godard, one of NACE's directors representing corporate membership and T. R. B. Watson, chairman of the Toronto Section will be speakers.

There will be 20 exhibits in connection with the meeting which will be held in the Yellow Room of the King Edward Hotel, in Toronto. Meeting times will be 2:30 to 11 pm.

New Shreveport Officers

The following new officers of the Shreveport Section took office January 1: William F. Levert, United Gas Pipe Line Co., chairman; Raymond C. Jordan, United Gas Pipe Line Co., vice-chairman; G. V. Jones, Arkansas-Louisiana Gas Co., secretary; M. A. Luby, Tretolite Co., treasurer; W. A. Broome, Arkansas-Louisiana Gas Co., trustee. All are of Shreveport.

60 See Inco Film

Sixty members and guests who attended Greater St. Louis Section meeting December 14, 1953 saw the color motion picture "Corrosion in Action" prepared by the Corrosion Engineering Section of the International Nickel Company, Inc. The film comprised the technical portion of the meeting.

Scientists Distinguished—

(Continued from Page 2)

ards, but now a part of the Department of Defense.

His major scientific interests are the application of electrical theory to corrosion and corrosion prevention and the development of power supplies by electrochemical methods. A native of Washington, D. C., he received BS and MS degrees in chemistry from University of Illinois in 1920 and 1921 and a PhD

degree from George Washington University in 1929.

Early Research on Aluminum

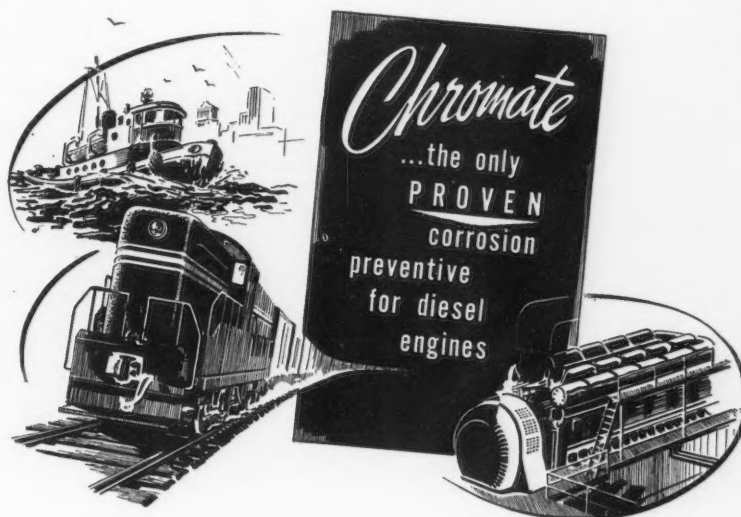
Mr. Dix, now assistant director of research of Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa., began his work on aluminum alloys in 1919 as Assistant Engineer of Tests, Aluminum Castings Company and continued in 1921 as Chief, Metals Branch, Engineering Division, Air Service, McCook Field, Dayton, Ohio. He received an ME in 1914 and MME in 1916 from Cornell University.

His major interest has been in the development of aluminum and magnesium alloys for industrial uses, an important consideration being the effect of metallurgical structure on the resistance to corrosion and stress corrosion and

the control of structure by composition and thermal treatment to get maximum resistance. He has given special attention to corrosion problems in aircraft.

He is a member of NACE, ASM, AIME, ASTM, SAE, AFS, AAAS and British Institute of Metals. He is a member of the Subcommittee on Aircraft Structural Materials, National Advisory Committee for Aeronautics.

Mr. Dix was 1940 Institute of Metals Lecturer, AIME and the 1949 Edward deMille Campbell Lecturer, ASM. In 1947 he was awarded the Francis J. Clamer Medal by the Franklin Institute in consideration of his meritorious contributions to the development of high strength corrosion resistant aluminum products. He is a member of Sigma Xi and an honorary member of Sigma Tau.



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Metallizing Discussed At Hamilton-Niagara Meeting December 16

Thirty-three members and guests at the December 16 meeting of the Hamilton-Niagara Section heard E. A. Mahaits, D. W. Deane & Co., Toronto and W. R. Wardrop, Metal-Cladding, Inc., Buffalo, N. Y., speak on metallizing. Metco's sound-color film showing many practical applications of metallizing was viewed. The film was augmented by slides and commentary by Mr. Wardrop. Mr. Mahaits explained the functions and operation of the metallizing gun and exhibited samples of metal coated by it. Following the films and talks there was a question and answer session.

Officers for 1954 for the section were elected at the meeting as follows: H. W. Hyslop, United Gas & Fuel Co., Hamilton, Ontario, chairman; R. J. Berkol, Atlas Steels Ltd., Welland, Ontario, vice-chairman and H. C. Wade, The Steel Co. of Canada, Ltd., Hamilton, Ontario, secretary-treasurer.

Welding Society to Meet

The American Welding Society will stage its second Welding & Allied Industry Exposition at the Memorial Auditorium, Buffalo, N. Y., May 5-7. In conjunction with the exposition the society's National Spring Technical Meeting will be held May 4-7 at the Hotel Statler.

NOTICE

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NACE MEETINGS CALENDAR

Feb.

- 1—Greater Kansas City Section. Construction and Application of the Magnetic Amplifier Rectifier, Daniel R. Werner. American Legion World War II Memorial, Kansas City.
- 3—Greater Boston Section. Protective Coatings, Lou Bake, E. I. du Pont de Nemours & Co., Inc. Wilmington, Del. Hotel Beaconsfield, Boston.
- 8—Greater St. Louis Section. Motion picture and discussion on the use of Fiberglas pipe wrap, John B. Roadhouse, Owens-Corning Fiberglas Corp., York Hotel.
- 9—Houston Section. General Aspects of Metallurgy in Corrosive Environments. Coffee speaker, Val Gene McCoy, "Public Relations Is Everybody's Business."
- 16—Cleveland Section. Management's Attitude Toward Corrosion Control, Les Cannon.
- 25—Detroit Section.

Mar.

- 8—Cleveland Section.
- 9—Houston Section. New Phases of Cathodic Protection, panel. Marshall E. Parker, Cormit Engineering Co., chairman.
- 30—Southwestern Ohio Section. Stress Corrosion by W. F. Beck. Talk illustrated by motion picture.

No date—Chicago Section.

Morton and Shankweiler To Talk at Philadelphia

Philadelphia Section's first meeting for 1954 will be held February 12. Two well known speakers will be guests of the section, B. B. Morton, Research and Development Division, International Nickel Company, will talk on "Corrosion Problems in the Petroleum and Related Fields," and F. K. Shankweiler, Chlorinated Products Sales Division, Hercules Powder Company, will discuss "Chlorinated Rubber Maintenance Coatings."

The nominating committee of Philadelphia Section announced at the section's December meeting the election of the following officers for 1954: H. H. Bennett, Socony-Vacuum Oil Co., Inc., Paulsboro, New Jersey, chairman; I. S. Pettibone, American Society for Testing Materials, 1916 Race St., Philadelphia, Pa., vice-chairman; S. F. Spencer, Keystone Shipping Co., Philadelphia, Pa., secretary-treasurer. They took office January 1.

Instrument Society

The 9th Annual Regional Conference, Instrument Society of America will be held February 4 at Hotel Statler, New York City. Power, process, medical and aviation groups will present papers on progress in measurement.

Shreveport Section's Short Course Scheduled To Be Held February 18-19

Shreveport Section's Annual Corrosion Short Course will be held at Centenary College, Shreveport, February 18-19. Registration fee of \$10 includes meals at Centenary College cafeteria and a banquet on the 18th. Registrations should be sent to and additional information may be obtained from G. V. Jones, Arkansas-Louisiana Gas Co., Box 1734, Shreveport.

The schedule has been announced as follows:

Thursday, February 18

- am
8-9:45—Registration, Science Bldg., Centenary
9-10—Introduction and welcoming remarks
10-11—Basic causes and control of corrosion
11-12—Economics of corrosion control
12-12:30—Management's view on corrosion control
pm
12:30—Lunch, Centenary Cafeteria
1:30-2:30—Underground protective coatings
2:30-3:30—Fundamentals of cathodic protection
3:30-4:30—Corrosion control in congested areas
5:30-6:30—Social hour
6:30-8—Banquet
8—Entertainment

Friday, February 19

- am
8:30-9:30—Above ground coatings
9:30-10:30—Plastics for corrosion control
10:30-11:30—Causes and mechanics of internal corrosion
11:30-12:30—Application of corrosion inhibitors in the oil and gas industry
pm
12:30—Lunch, Centenary Cafeteria
1:30-2:30—Plant and vessel corrosion
2:30-3:30—Inspection and field testing practices for internal corrosion
3:30—Round table discussion on corrosion and corrosion control.

Tulsa Section's Annual Short Course Is Feb. 17-19

The Fifth Annual Tulsa NACE Section Short Course for Pipeliners on practical control of pipeline corrosion is scheduled for February 17-19 at the Mayo Hotel, Tulsa. Several field trips will be offered.

Fred M. Cloninger, The Texas Pipe Line Company, general chairman, said the program will be similar to that of previous courses with discussions on how and what to do to minimize corrosion. The theme will be the right way and the wrong way to make field installations.

Requests for reprints of technical or other material published in CORROSION should be addressed to NACE's Central Office, 1061 M & M Bldg., Houston 2, Texas.

Panel on Cathodic Protection Scheduled for March Dinner Meeting of Houston Section

Holmberg Speaks on Valve Design Dec. 11 At Philadelphia Meeting

E. G. Holmberg, Chief Metallurgist, Alloy Steel Products Co., Linden, New Jersey, was the speaker for the technical portion of the December 11 meeting of the Philadelphia Section. Mr. Holmberg spoke on Design Considerations for Corrosion Resistant Valves. Some of the important corrosion processes, with which an engineer should be familiar when designing equipment to handle corrosive fluids were described. Results of field corrosion tests, conducted in various media, were reviewed. These data showed the effects of alloy composition modifications on corrosion resistance and the effect of solution contaminants on corrosivity. The importance of selecting the proper alloy for a particular service was stressed. Specific features employed in the construction of corrosion resistant valves, as well as valves designed to perform specific operations were described.

Joint ASTM-North Texas Section Meet Scheduled

North Texas Section NACE and the American Society for Testing Materials will hold a joint meeting in Dallas February 15. The meeting will hear Leslie C. Beard, Jr., assistant director of Socony-Vacuum Laboratories and ASTM president speak on "Something Has Been Added." His talk concerns additives to petroleum products designed to impart among other things anti-rust properties. He estimates the value of petroleum additives to be \$400,000,000 annually.

Mr. Beard will make the same address at Houston February 17 at a public meeting at Cullen Auditorium, University of Houston. Members of Houston area technical organizations including NACE have been invited to attend.

Tubing Caliper Talk Heard by Teche Section

Robert S. Martin, Tuboscope Co., Houston, was technical speaker at Teche Section's December 10 meeting. His topic was evaluation of internal corrosion of tubing by caliper survey. He said with caliper surveys both the waste of unnecessarily replacing pipe that is still good and the considerable expense occurring from production-string failures are eliminated. Mr. Martin illustrated his talk with numerous slides and exhibited various instruments used by his company in making caliper surveys. After the talk Mr. Martin answered questions of the 32 members and guests present.

Additional copies of CORROSION are available at 50c each to NACE members and \$1 each to non-members.

New Phases of Cathodic Protection will be discussed by a panel at the March meeting Houston Section. Chairman of the panel will be Marshall E. Parker, the Cormit Engineering Co., Houston. An attempt will be made to keep discussion on the most recent developments and problems in cathodic protection, according to Mr. Parker. Coffee speaker for the meeting will be Val Gene McCoy of the Shell Oil Co. who will speak on "Public Relations Is Everybody's Business." The meeting will be held March 9, at Kelley's Dining Room.

"One of the best meetings of the year," was the consensus of the 132 members and guests attending the January 12 meeting Houston Section. The technical program consisted of a panel on off-shore structures and in place of a coffee speaker, a movie of the quenching of an oil well afire in the Gulf of Mexico was shown. The difficult problems of protecting offshore platforms and structures for drilling wells and handling oil production were discussed.

Most critical of all corrosion areas in these structures lies within the "splash zone." This is the area from the waterline to six or eight feet above the waterline. Most members of the panel were of the opinion that a concrete coating offered good protection in this critical zone. Recently some firms are cladding exposed structural parts with Money metal before a coating is applied. Use of fish oil or a heavy grease-like inhibitor as a coating also has been tried. For the underwater portion of the structures, cathodic protection was the most widely used preventive of corrosion, according to panel members.

On the panel were H. E. Waldrip, Gulf Oil Corp., P. P. Spafford, Stanolind Oil and Gas Co., W. H. Edwards, Superior Oil Co., J. L. Battle, Humble Oil and Refining Co. and C. J. Fritts, Magnolia Petroleum Co.

R. A. GOODALL

Robert A. Goodall, president of Good-All Electric Manufacturing Co., Ogalalla, Nebraska and a corporate representative of his company in the National Association of Corrosion Engineers, died October 22.

WALTER R. MOUNT

Walter R. Mount, a member of the Canadian Regional Division, NACE, died early in 1953. Mr. Mount had been a member of NACE since 1948. At the time of his death he was Superintendent of the Waterworks Distribution System of the City of Edmonton, Alberta, Canada.

WALTER J. SANDEL

Walter J. Sandel, a member of the Cleveland Section, NACE, died December 16. Mr. Sandel has been a member of NACE since 1947. At the time of his death he was the Amercoat Field Representative in the Ohio, Kentucky and Michigan area.

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Sabine-Neches Section To Hear Hackerman

Dr. Norman Hackerman, Chairman of the Department of Chemistry, University of Texas, Austin, was the speaker at the January 28 meeting of the Sabine-Neches Section. Because Dr. Hackerman is nationally prominent in the field of corrosion prevention the section decided to designate the January 28 meeting "Bosses' Night." Section members were urged to make every effort to get top management of their respective organizations to attend the meeting. Dr. Hackerman's topic was corrosion inhibition.

Bilhartz Elected Head Of South Central Region

Tellers appointed to handle the election of the 1954 officers for the South Central Regional Division announced results of the election as follows: H. L. Bilhartz, Atlantic Refining Co., Dallas, chairman; Clifford L. Barr, Shell Oil Co., New Orleans, La., vice-chairman; John E. Loeffler, Thornhill-Craver Co., Houston, secretary-treasurer; John W. Nee, Briner Paint Mfg. Co., Inc., Corpus Christi, assistant secretary-treasurer. They took office January 1.

Indices to each volume of Corrosion are published in the December, the twelfth and last issue of each year.

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Keeling and Lombardo Talk at San Francisco

Western Regional Division met in Los Angeles on January 13. The program consisted of two speakers: H. J. Keeling, Consulting Engineer, Los Angeles, spoke on Corrosion Circuit Theory and Miss Flora Lombardo, research chemist, Amercoat Corp., Southgate, Cal., discussed Development of Organic Coatings for Resistance to Marine Corrosion. New officers elected for 1954 were installed as follows: Robert H. Kerr, Southern California Gas Co., Los Angeles, chairman; Dean E. Stephan, Chicago Bridge & Iron Co., Los Angeles, vice-chairman; R. E. Hall, Union Oil Co., Brea, Cal., secretary-treasurer.

Crowdus Talks at Dallas On Cooling Water Problems

R. R. Crowdus, Dallas Power & Light Co., Dallas, spoke on Cooling Water Problems before 44 members and 29 guests at the January 4 meeting of North Texas Section. New officers for the section's 1954 season were installed as follows: J. Gordon Meek, Metal Goods Corp., Dallas, chairman; Paul C. Fleming, Gulf Oil Corp., Ft. Worth, vice-chairman; Charles L. Slover, Keith-Kote Co., Grand Prairie, secretary-treasurer.

Kopp Is Chairman of Central Oklahoma Group

In a recent election the Central Oklahoma Section named new officers for 1954. Elected were: C. H. Kopp, Peppers Refining Co., Oklahoma City, chairman; Clyde C. Allen, Anderson-Prichard Oil Corp., Oklahoma City, vice-chairman; Loyd Goodson, Oklahoma Natural Gas Co., Shawnee, Oklahoma, secretary-treasurer and Dan H. Carpenter, Sohio Petroleum Co., Oklahoma City, section trustee.

ISC Committee CORROSION MEETINGS CALENDAR

1954

Feb.

- 15-18 American Institute of Mining and Metallurgical Engineers, Annual Meeting, Statler Hotel, New York, N. Y.
- 25 The Chemical Institute of Canada, Eighth Divisional Conference, Protective Coatings Division, Montreal and Toronto, Canada.

Mar.

- 1-5 American Society for Testing Materials, Spring Meeting, Shoreham Hotel, Washington, D. C.
- 4-5 American Gas Association, Transmission and Storage Conference, Jung Hotel, New Orleans, La.
- 15-17 Mid-West Gas Association, Fort Des Moines Hotel, Des Moines, Iowa.
- 15-19 National Association of Corrosion Engineers, Annual Conference and Exhibition, Municipal Auditorium, Kansas City, Missouri.

- 16-18 American Railway Engineering Association, Annual Meeting, Palmer House, Chicago, Illinois.
- 25-26 New England Gas Association, Hotel Statler, Boston, Mass.
- 25-26 Oklahoma Utilities Association, Annual Meeting, Biltmore Hotel, Oklahoma City, Okla.

April

- 20-23 Indiana Gas Association, Annual Meeting, French Lick Springs Hotel, French Lick, Indiana.
- 20-23 American Gas Association, Distribution, Motor Vehicles and Corrosion Conference, Mount Royal Hotel, Montreal, Canada.
- 26-28 Southern Gas Association, Annual Convention, Houston, Texas.

May

- 17-18 Society of Naval Architects and Marine Engineers, Spring Meeting, Olympic Hotel, Seattle, Washington.
- 24-26 American Gas Association, Production and Chemical Conference, William Penn Hotel, Pittsburgh, Pa.
- 27-28 Natural Gas and Petroleum Association of Canada, Prince Albert Hotel, Windsor, Ontario, Canada.

June

- 12-25 American Institute of Electrical Engineers, General Summer Meeting, Biltmore Hotel, Los Angeles, Calif.
- 13-18 American Society for Testing Materials, Annual Meeting and Exhibit, Sherman Hotel, Chicago, Illinois.
- 20-24 Canadian Gas Association, Banff Springs Hotel, Banff, Alberta, Canada.
- 28-29 Michigan Gas Association, The Grand Hotel, Mackinac Island, Michigan.
- (No Date) National District Heating Association, Annual meeting.

July

- 11-14 American Society of Refrigerating Engineers, Hotel Olympic, Seattle, Washington.

Sept.

- 8-10 Pacific Coast Gas Association, Victoria, British Columbia.
- 28-29 Texas Mid-Continent Oil and Gas Association, Baker Hotel, Dallas, Texas.

Oct.

- 3-7 The Electrochemical Society, Fall Meeting, Boston, Mass.
- 11-14 American Gas Association, Annual Convention, Atlantic City, New Jersey.
- 11-15 American Institute of Electrical Engineers, General Fall meeting, Hotel Morrison, Chicago, Ill.
- 12-15 National Association of Corrosion Engineers, South Central Regional Meeting, Dallas, Texas.

Nov.

- 1-3 American Institute of Mining and Metallurgical Engineers, Institute of Metals Division, Fall Meeting, Sheraton Hotel, Chicago, Ill.
- 1-5 National Metal Exposition, Chicago, Illinois.
- 8-11 American Petroleum Institute, Conrad Hilton Hotel, Chicago, Illinois.
- 15-18 American Gas Association, Operating Section, Organization Meetings, Hotel New Yorker, New York, N. Y.

Two New Committees Announced by TP-6

Two new subcommittees were announced and reports from other subcommittees were included in the 1953 annual report of Technical Practices Committee No. 6 on Protective Coatings. The report was made by A. J. Liebman, Pittmar Centrifugal Machine Corp., Pittsburgh, Pa., chairman of the committee to H. W. Schmidt, The Dow Chemical Co. Midland, Mich. chairman of the NACE Technical Practices Committee.

Technical Practices Subcommittee No. 6R was added specifically to cover the study of new projects on protective coatings that should become part of Technical Practices Committee No. 6. The new committee would also consider projects undertaken by societies other than NACE to avoid duplication of effort on projects. An attempt will be made to secure committee members who also are members of other scientific societies with purposes similar to those of NACE. Chairman of Technical Practices Subcommittee No. 6R is Dr. Robert H. Steiner Atlas Mineral Products Co., Mertztown, Pa.

The other new committee has been designated Technical Practices Subcommittee No. 6L, Asphalt Type Underground Protective Coatings. R. J. Schmidt, California Research Corp., San Francisco, Cal., is the chairman. The committee was formed in May, 1953, and according to Mr. Liebman appears to be making good headway in organizing its problems. It is expected a progress report will be made at a meeting in Kansas City during the NACE Conference and Exhibition, March 15-19.

In addition to the two newly organized committees, plans are underway to form a third new subcommittee during 1954. The new committee would have bituminous coatings as its subject.

In its first report since its organization, Technical Practices No. 6A, Organic Coatings and Linings for Resistance to Chemical Corrosion, presented a general outline for organic coatings and linings along with specific interpretations of coating characteristics, film thicknesses and drying time. Work is being continued and an enlarged report will be presented at the coming meeting of NACE.

Considerable data on organic coatings suitable for atmospheric exposure has been compiled and a complete chart system is being developed as a result of activities of Technical Practices Subcommittee No. 6B, Protective Coatings for Resistance to Atmospheric Corrosion. A report of this committee was submitted in March, 1953, and reviewed in June. Further discussions are being planned for March, 1954.

A report on its activities was made by Technical Practices Subcommittee No. 6C, Protective Coatings for Resistance to Marine Corrosion. The finished, edited report will probably be completed for the Spring meeting.

The complete and final report of Technical Practices Subcommittee No. 6G, Surface Preparation for Organic Coatings, was published in the May, 1953, issue of CORROSION. The report was titled: "Report on Surface Preparation of Steels for Organic and Other Protec-

tive Coatings." It was the second interim report of the committee, the first interim report having been published in the August, 1950, issue of CORROSION. Many reprints of these reports have been sold.

The progress of Technical Practices Subcommittee No. 6H, Glass Linings and Vitreous Enamel will be reported on at the Kansas City meeting at the Annual Conference and Exhibition. Selection of a new chairman is now underway for Technical Practices Subcommittee No. 6E, Protective Coatings in Petroleum Production. Jack Barrett, Stanolind Oil and Gas Co., Tulsa, Okla., former chairman, resigned.

Additional copies of CORROSION are available at 50c each to NACE members and \$1 to non-members.

River Pollution Curbed

Substantial progress in curbing new pollution and decreasing existing pollution of the Ohio River valley water shed is reported by the Ohio River Valley Water Sanitation Commission. This 8-state group has been in existence five years, and its fifth annual report itemizes progress made. Copies of the report may be obtained on request from the commission, 414 Walnut St., Cincinnati 2, Ohio.

At a hearing scheduled December 9 at Louisville, Ky. the commission presented findings on the recommendations for treating sewage discharged by municipalities into the Ohio River between Cairo, Ill. and Cincinnati.

FEDERATED METALS OFFERS NEW REPORT: "CATHODIC PROTECTION WITH ZINC ANODES"

Federated's Corrosion Advisory Service offers you, without obligation, a new report titled, "Cathodic Protection With Zinc Anodes," prepared by Ebasco Services Inc. for the American Zinc Institute. This new publication reports additional findings obtained since the first report was issued in November, 1951. In it you will find important and valuable facts that have influence on the proper applications of zinc anodes. Use coupon below for your free copy.

Zinc Anodes are available from Federated in standard lengths of 3 ft. and 5 ft. They are cast of Special High Grade Electrolytic Zinc in cross-sections of 2 sq. in. and 4 sq. in. Each has full length chemically-bonded steel core rod. Silver-soldered connecting wires can be attached if desired.

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AIChE Hears Several Papers on Corrosion

The following papers containing information significant to corrosion workers were presented at the December 15 meeting of American Institute of Chemical Engineers at St. Louis:

Research in Industrial Pollution Control. By Roy F. Weston, Sanitary Engineer, Atlantic Refining Company, Philadelphia, Pa. The author says that although industry is spending hundreds of thousands of dollars annually on research seeking a low cost solution of industrial waste disposal problems much remains to be done to transform the art into a science.

Operating Experience—Catalytic Oxidation of Aqueous Wastes. By John Oliver, Assistant Manager Belle Works, E. I. duPont de Nemours & Co., Charleston, W. Va. Operation of the plant for disposing of organic wastes is described.

The Place of Aquatic Biology in the Field of Stream Pollution. By Charles E. Renn, Professor of Sanitary Engineering, Johns Hopkins University, Baltimore. The science of pollution control will become more realistic when working requirements for waste abatement are based on real performance reflected in the life in the receiving stream.

The Use of Ion Exchange in the Waste Treatment Field. By C. F. Paulson and A. B. Mindler, Special Applications Department, The Permutit Company, New York, N. Y. Ion exchange

treatment of wastes is practical only when some part of the waste is reclaimable or usable, such as a dissolved constituent or heat. Ion exchange can effect a striking concentration of the electrolyte and make possible more economical disposal.

The Integrated Waste Treatment System for the Metal Finishing Industry. By L. E. Lancy, Consulting Engineer, Elwood City, Pa. Closed circulation systems in which toxic compounds are washed from work are described.

Water Balance—A Primary Key for Industrial Waste Control. By A. N. Heller and M. E. Wenger, Barrett Div., Allied Chemical & Dye Corp., New York, N. Y. Operations at the Barrett Division's Frankfort Works whereby an economic solution to waste control was achieved by applying chemical engineering principles to water balance, material balance, heat balance, unit operation modification and recycling. Water demand was reduced from 17,427,000 gallons in 1948 to 783,000 gallons in 1953 and gallons of waste discharge reduced from 18,408,000 to 535,000 gallons.

The American Institute of Chemical Engineers meeting was told of new methods for removing suspended dusts and mists from air. Dusts and mists are important contributors to atmospheric pollution as well as causes for substantial economic losses to industry.

Large sums of money are being spent currently by industry and governmental agencies in studying the air pollution problem and developing suitable preventive measures.

Prof. C. E. Lapple of Ohio State University, presided and introduced the symposium with a general discussion of the selection and design of equipment for collecting dusts and mists. K. J. Caplan, consulting engineer of St. Louis; A. G. Blasewitz of the General Electric Company, Richland, Washington; H. J. Kamack of the du Pont Company, Wilmington, Delaware and G. A. Johnson of Harvard University, spoke on performance of various types of equipment for removing dusts and mists. Dr. G. R. Gillespie of the University of Illinois and Dr. J. M. Dalla Valle of Georgia Institute of Technology discussed the properties of dusts and mists and their measurement.

NBS Sustained in Battery Additive Probe

Conclusions in the report of the Committee on Battery Additives of the National Academy of Sciences have been published in a 35-page booklet. The committee had as its objective, the appraisal of the quality of the work performed by the National Bureau of Standards in relation to Battery AD-X2, the battery additive which was the center of considerable controversy among the Senate Small Business Committee and other government agencies last year.

Conclusions of the National Academy of Sciences' Committee was that the quality of work in the field of lead acid storage battery testing done by the National Bureau of Standards is excellent and that relevant data available to the committee supports the position of the bureau that the additive material is without merit.



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Columbia University Research on Corrosion

Engineering research underway at Columbia University Engineering Center, New York City as reported in the Columbia Research News 1954 annual edition include the following of corrosion interest:

Migration of moisture in granular material is being studied with radioactive tracers to determine if controlling the moisture content of the soil adjacent to power cables will not permit increasing their load.

An electrolytic extraction process for titanium expected to reduce its price has been developed.

An electrolytic extraction process for zirconium is being developed.

A comprehensive series of graphs is being made plotting free-energy of formation against temperature for metal compounds such as oxides, sulfides, carbonates, sulfates, chlorides, fluorides, bromides, iodides, carbides, nitrides, hydrides and others.

Symposium on Industrial Hygiene Instruments

Included in a "Symposium on Instrumentation" for makers and users of instruments for industrial hygiene to be held May 24-27 at University of Michigan, Ann Arbor, is a program entitled "Atmospheric Pollution Evaluation." The program will include exhibits, discussions and technical papers and is sponsored by the university's Industrial Health and School of Public Health. An illustrated book of the proceedings will be published.

Technical Books Are Asked for Haifa Technion

Journals and books for the technical library of Haifa Technion in Israel are being collected by Worcester Chapter, American Technion Society. Haifa Technion is the only engineering school in the Near East. Anyone who wishes to donate books or journals to the school is invited to write to Dr. B. D. Halpern, Monomer-Polymer, Inc., Leominster, Mass.

Articles on meetings pertaining to corrosion control held anywhere in the world are welcomed for publication in CORROSION, NACE official monthly magazine.

Spectrographers to Meet

American Association of Spectrographers will present a symposium on "Direct Reading Emission Spectroscopy," at Chicago on May 7. The following subdivisions will be made in the symposium: iron and steel, non-ferrous metals and metal in non-metallic materials. Contributed papers will be welcomed by M. E. Slagel, Symposium Chairman, U. S. Reduction Co., Box 30, East Chicago, Ind.

Equipment Obsolete

American industry, by its own figures, estimates that 28 percent of its production equipment and manufacturing processes are now obsolete or inadequate, according to an industry-wide survey by the American Society of Tool Engineers. Processes and types of equipment covered were: machining equipment, inspection methods, materials handling equipment and processes, metal forming processes, production welding equipment and grinding and finishing equipment.

Students Honored

David J. Barnette and Paul Farrar of New York University's College of Engineering have been awarded first prize for scientific papers from regional engineering students by New York Section, American Institute of Mining and Metallurgical Engineers. This is the fourth successive year NYU students have taken first prize.

G. E. PURDY



G. E. Purdy of Tretolite Company is shown here delivering an address at Western Region's 1953 Fall Meeting at Los Angeles. Mr. Purdy was identified incorrectly on Page 5, January, 1954 issue of Corrosion as Howard D. Segool of The Kendall Company.

POSITIONS WANTED and AVAILABLE

- Active and Junior NACE members may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.
- Firms seeking employees, regardless of NACE membership, may run an advertisement of the same specifications indefinitely.
- Advertisements to other specifications will be charged for at standard rates.

Positions Available

Corrosion Engineers. Positions available for graduate electrical engineers or equal. Previous field and design experience in corrosion mitigation systems required. Extensive travel involved. Salary open. The Hinchman Corp., Engineers, Francis Palms Bldg., Detroit 1, Mich.

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NEW PRODUCTS — Materials — Service — Literature

Diatomite Filters, used for filtering oil from contaminated water among other things are described in a bulletin titled *Diatomite Filters* available from General Filter Company, 923 Second St., Ames, Iowa.

Globe Stainless Steel Tubes are described in a bulletin by that name available from Globe Steel Tubes Co., Milwaukee 46, Wis.

An Electro-Pneumatic Tube Rolling Control that combines advantages of air operation with precise electrical control is available from Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill. The device can roll tubes up to 2½ inches OD with exactness minimizing possibility of distortion, fracture or cold work crystallization.

Alcoa Aluminum Corrugated Industrial Roofing and Siding, AIA File No. 12C, a bulletin describing the physical characteristics of aluminum corrugated sheeting and illustrating recommended application methods is available on request from Alcoa, 804 Alcoa Bldg., Pittsburgh 19, Pa.

Cyclonaire, a portable fume washer, is described and illustrated in a bulletin available from Kenneth Bullock, The U. S. Stoneware Company, Process Equipment Div., Akron 9, Ohio. The units may be used singly or in series and are protected against corrosion by Tygoflex plastic. High washing efficiency from the company's Intalox Saddle Packing is claimed.

Cast High Alloys, reprint of a technical article by E. A. Shofer, executive vice-president, Alloy Casting Institute is now available from The Cooper Alloy

Foundry Co., Hillside, N. J. Cast corrosion resistant alloys are discussed. Tables of mechanical and physical properties are included and chemical composition ranges for heat and corrosion resistant castings covered.

Harvey 66S, a high strength, low cost aluminum alloy with corrosion resistance similar to 61S, far greater than that of 24S and 14S has been developed by Harvey Aluminum of Torrance, Cal.

A Resin Cement mortar developed by Atlas Mineral Products Company, Mertztown, Pa. which can be applied on vertical and ceiling joints without difficulty has superior resistance to alkalis, acids, solvents and salts at temperatures up to 375 degrees F.

Lunn Laminates, Inc., Huntington Station, L. I. and Ashtabula, Ohio has signed a prime contract with Chevrolet Division of General Motors to make reinforced plastic body parts for Chevrolet's Corvette, a new high-horsepower, sports car to be produced in limited numbers.

Comparative Corrosion resistance of stainless tubing and pipe is tabulated in a folder available from Tubular Products Div., Babcock & Wilcox Co., Beaver Falls, Pa. Bulletin TDC 160 presents data on six widely used stainless tubing steels and several hundred corrosive media at various temperatures and concentrations.

Precipitron electrostatic air cleaners designed for integration in home ventilating and heating systems are available from Westinghouse Electric Corp., 401 Liberty Ave., Box 2278, Pittsburgh 30, Pa. The 200-lb unit, which can be at-

tached to walls or ceiling, is effective even against tobacco smoke and handles from 1000 to 1200 cubic feet of air a minute. Water and drain line connections for removing accumulated dust are available.

Guide to Improved Packaging with Bakelite, a new bulletin on materials useful in packaging of all kinds of materials is available on request from Bakelite Co., Division Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y.

H. M. Harper Co. has moved its New York City operation to a new 15,000-square-foot building at 225 Hoyt Ave., Mamaroneck, N. Y.

Erchlor 1900, a synthetic rubber coating designed for surfaces where standard chlorinated rubber finishes do not have satisfactory life has been developed by Earl Paint Corp., 240 Genesee St., Utica 2, N. Y. Recommended for surfaces in paper mills and for outside service on traction machinery, it incorporates chemical resistant plasticizers and synthetic resins. Manufacturers report it dries to a non-flammable finish after application by brush or spray.

Camac Hose Valves, with a contoured design intended to prevent hose damage, will give complete shut-off against pressures up to 100 psi. They are constructed of aluminum and bronze and made in sizes suitable for hoses from one to 2½ inches OD by Carl Buck and Associates, P. O. Box 267, Essex Falls, N. J.

Elgiloy, developed by Elgin National Watch Co., Abrasives Div., Elgin, Ill. for watch springs, but suitable for a wide variety of other springing and product applications is now available for general industrial use. Manufacturers say the alloy is highly resistant to corrosion and fatigue, highly elastic, has high tensile strength and can be soldered, welded, brazed, punched or formed. Machining is best when done by carbide-tipped tools. A series of 50-hour laboratory tests comparing the alloy with 18-8 Mo and 17% Chrome steels at temperatures from 75 to 254 degrees F in a number of acids and alkalis at various concentrations shows it to be superior in corrosion resistance to the other two materials in all but a few instances.


Borolite Corp., Niagara Falls, N. Y. will expand its activities as a consequence of the amalgamation of activities in the high temperature boride field by Firth Sterling, Inc., American Electro Metal Corp., and the Corborundum Company. The company will pursue research and development of metal borides for military and industrial uses which formerly was individually under way by the three companies concerned. Borides, carbides and aluminides show promise of withstanding operating temperatures ranging from 1600 to 2000 degrees F in turbojets and up to 7000 degrees F in rocket nozzles and intermediate applications.

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(Continued on Page 14)

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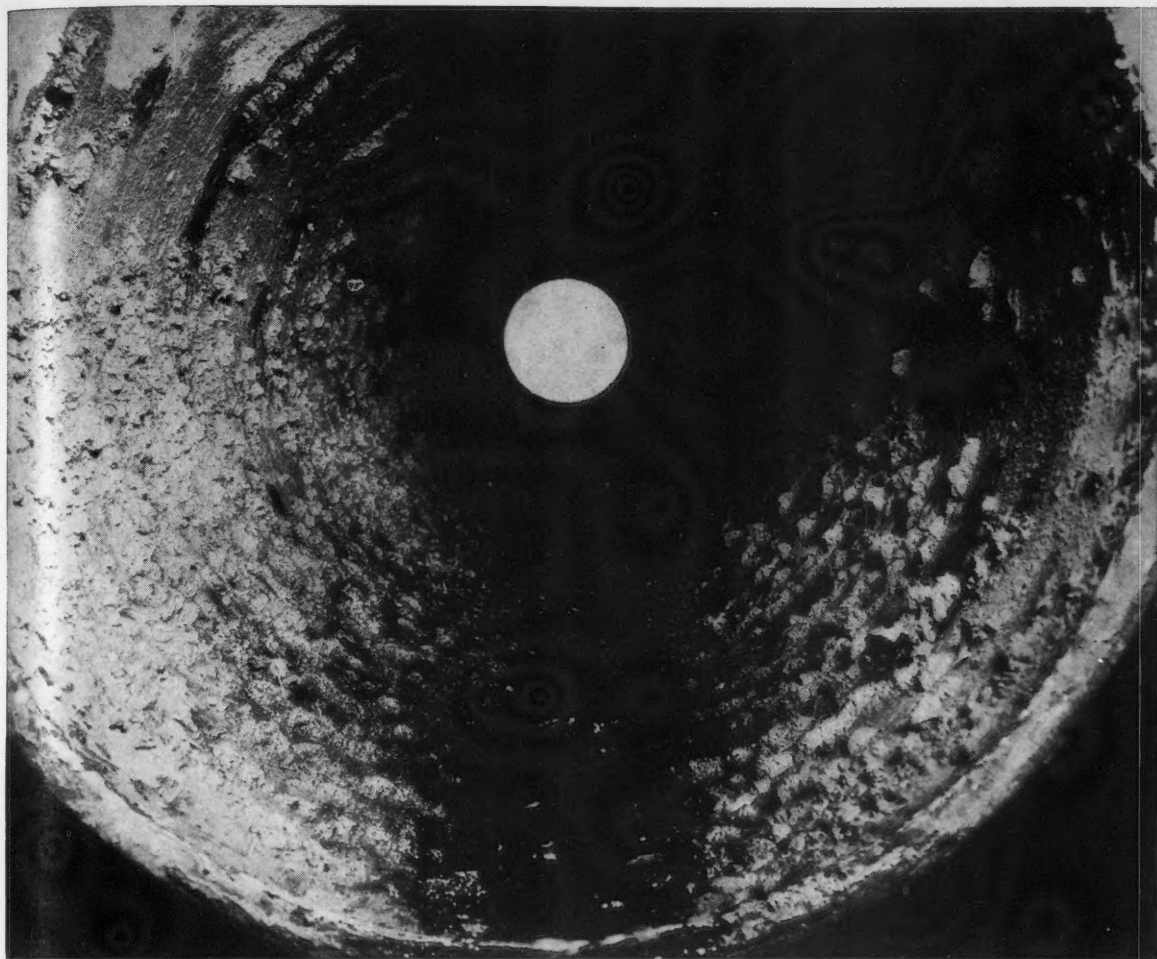
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Don't let your pipeline get "TB"

Tuberculated pipe is only one of many hazards which drastically reduce pipeline efficiency. You can avoid this condition responsible for capacity losses by specifying Barrett Waterworks Enamel for pipeline operations.

You benefit in two distinct ways. First, Barrett Waterworks Enamel is of the highest quality, meeting all A.W.W.A. standards. Second, whenever and wherever Barrett Waterworks Enamel is used, the services of Barrett's Service Representatives are available. These highly trained and experienced pipeline engineers assist you from the planning stage, where the exact coating to meet specific needs is determined, right through to the mill and pipeline site where Barrett coal-tar enamels are applied.

That's why it pays to specify Barrett. You get the best protective coatings possible, plus expertly supervised application.

Listed here are 10 definite advantages of Barrett Waterworks Enamel:

- Rigid quality control
- Prevents tuberculation and incrustation of interior pipe surfaces
- Effectively protects external pipe surfaces against corrosion
- High ductility and flexibility, high resistance to soil stresses
- Unusual tenacity
- Effective under all kinds of climatic conditions and topography
- Quick service
- Wide availability
- High dielectric properties
- Impermeable to moisture, non-absorptive, non-porous

Barrett Division, Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y. In Canada: The Barrett Company, Ltd., 5551 St. Hubert St., Montreal.



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BARRETT PROTECTIVE COATINGS

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NEW PRODUCTS — Materials — Service — Literature

Diatomite Filters, used for filtering oil from contaminated water among other things are described in a bulletin titled *Diatomite Filters* available from General Filter Company, 923 Second St., Ames, Iowa.

Globe Stainless Steel Tubes are described in a bulletin by that name available from Globe Steel Tubes Co., Milwaukee 46, Wis.

An Electro-Pneumatic Tube Rolling Control that combines advantages of air operation with precise electrical control is available from Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill. The device can roll tubes up to 2½ inches OD with exactness minimizing possibility of distortion, fracture or cold work crystallization.

Alcoa Aluminum Corrugated Industrial Roofing and Siding, AIA File No. 12C, a bulletin describing the physical characteristics of aluminum corrugated sheeting and illustrating recommended application methods is available on request from Alcoa, 804 Alcoa Bldg., Pittsburgh 19, Pa.

Cyclonaire, a portable fume washer, is described and illustrated in a bulletin available from Kenneth Bullock, The U. S. Stoneware Company, Process Equipment Div., Akron 9, Ohio. The units may be used singly or in series and are protected against corrosion by Tygoflex plastic. High washing efficiency from the company's Intalox Saddle Packing is claimed.

Cast High Alloys, reprint of a technical article by E. A. Shoefer, executive vice-president, Alloy Casting Institute is now available from The Cooper Alloy

Foundry Co., Hillside, N. J. Cast corrosion resistant alloys are discussed. Tables of mechanical and physical properties are included and chemical composition ranges for heat and corrosion resistant castings covered.

Harvey 66S, a high strength, low cost aluminum alloy with corrosion resistance similar to 61S, far greater than that of 24S and 14S has been developed by Harvey Aluminum of Torrance, Cal.

A Resin Cement mortar developed by Atlas Mineral Products Company, Mertztown, Pa. which can be applied on vertical and ceiling joints without difficulty has superior resistance to alkalis, acids, solvents and salts at temperatures up to 375 degrees F.

Lunn Laminates, Inc., Huntington Station, L. I. and Ashtabula, Ohio has signed a prime contract with Chevrolet Division of General Motors to make reinforced plastic body parts for Chevrolet's Corvette, a new high-horsepower, sports car to be produced in limited numbers.

Comparative Corrosion resistance of stainless tubing and pipe is tabulated in a folder available from Tubular Products Div., Babcock & Wilcox Co., Beaver Falls, Pa. Bulletin TDC 160 presents data on six widely used stainless tubing steels and several hundred corrosive media at various temperatures and concentrations.

Precipitron electrostatic air cleaners designed for integration in home ventilating and heating systems are available from Westinghouse Electric Corp., 401 Liberty Ave., Box 2278, Pittsburgh 30, Pa. The 200-lb unit, which can be at-

tached to walls or ceiling, is effective even against tobacco smoke and handles from 1000 to 1200 cubic feet of air a minute. Water and drain line connections for removing accumulated dust are available.

Guide to Improved Packaging with Bakelite, a new bulletin on materials useful in packaging of all kinds of materials is available on request from Bakelite Co., Division Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y.

H. M. Harper Co. has moved its New York City operation to a new 15,000-square-foot building at 225 Hoyt Ave., Mamaroneck, N. Y.

Erchlor 1900, a synthetic rubber coating designed for surfaces where standard chlorinated rubber finishes do not have satisfactory life has been developed by Earl Paint Corp., 240 Genesee St., Utica 2, N. Y. Recommended for surfaces in paper mills and for outside service on traction machinery, it incorporates chemical resistant plasticizers and synthetic resins. Manufacturers report it dries to a non-flammable finish after application by brush or spray.

Camac Hose Valves, with a contoured design intended to prevent hose damage, will give complete shut-off against pressures up to 100 psi. They are constructed of aluminum and bronze and made in sizes suitable for hoses from one to 2½ inches OD by Carl Buck and Associates, P. O. Box 267, Essex Falls, N. J.

Elgiloy, developed by Elgin National Watch Co., Abrasives Div., Elgin, Ill. for watch springs, but suitable for a wide variety of other springing and product applications is now available for general industrial use. Manufacturers say the alloy is highly resistant to corrosion and fatigue, highly elastic, has high tensile strength and can be soldered, welded, brazed, punched or formed. Machining is best when done by carbide-tipped tools. A series of 50-hour laboratory tests comparing the alloy with 18-8 Mo and 17% Chrome steels at temperatures from 75 to 254 degrees F in a number of acids and alkalis at various concentrations shows it to be superior in corrosion resistance to the other two materials in all but a few instances.

Borolite Corp., Niagara Falls, N. Y. will expand its activities as a consequence of the amalgamation of activities in the high temperature boride field by Firth Sterling, Inc., American Electro Metal Corp., and the Corborundum Company. The company will pursue research and development of metal borides for military and industrial uses which formerly was individually under way by the three companies concerned. Borides, carbides and aluminides show promise of withstanding operating temperatures ranging from 1600 to 2000 degrees F in turbojets and up to 7000 degrees F in rocket nozzles and intermediate applications.

(Continued on Page 14)

Now FOR THE FIRST TIME **GLASS LINED STEEL PIPE**
in long lengths at low cost!

For high temperature applications
contaminating liquids
corrosive conditions

To provide: smooth surface, low friction
abrasive resistance • sanitation

3" maximum outside dia. x 21' maximum length
Finished inside or outside—or both

USED IN: Pre-Heaters Heat Exchangers
Transportation Equipment
Reactor Tubes Salt Water Lines

Also available from Barrows: Ceramic coated stainless
steel and inconel tubes for external temperatures and
contamination in petro-chemical processes.

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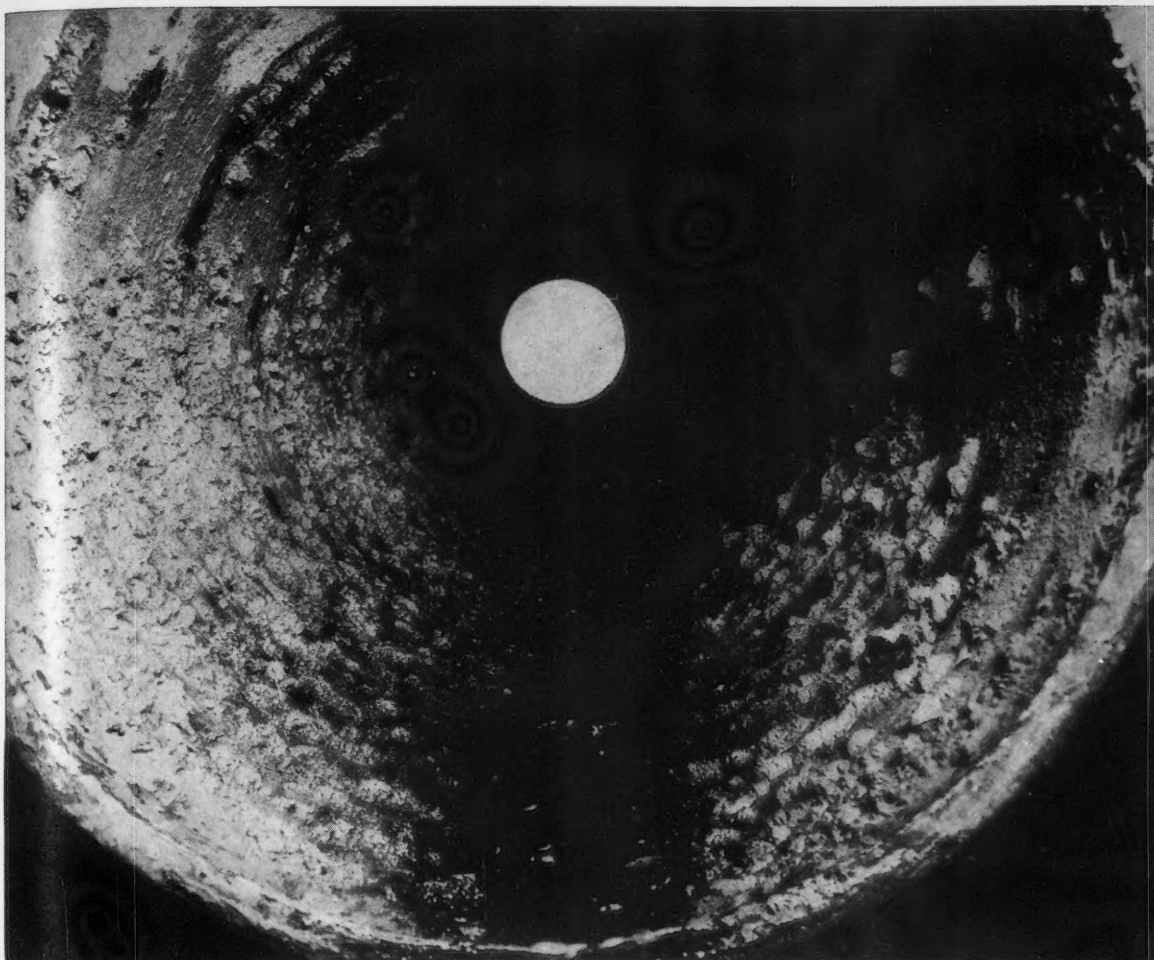


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Don't let your pipeline get "TB"

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You benefit in two distinct ways. First, Barrett Waterworks Enamel is of the highest quality, meeting all A.W.W.A. standards. Second, whenever and wherever Barrett Waterworks Enamel is used, the services of Barrett's Service Representatives are available. These highly trained and experienced pipeline engineers assist you from the planning stage, where the exact coating to meet specific needs is determined, right through to the mill and pipeline site where Barrett coal-tar enamels are applied.

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- Wide availability
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- Impermeable to moisture, non-absorptive, non-porous

Barrett Division, Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y. In Canada: The Barrett Company, Ltd., 5551 St. Hubert St., Montreal.



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BARRETT PROTECTIVE COATINGS

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NEW PRODUCTS

(Continued From Page 12)

Disposable neoprene impregnated paper work caps developed by E. I. du Pont de Nemours & Co., Inc. for use in one of its chemical plants are now available from Record Industrial Co., 3301 Arch St., Philadelphia 4, Pa. The caps are waterproof, flame retardant and do not collect dust as readily as cloth caps.

Santolene H, a fuel oil additive manufactured by Monsanto Chemical Co., Organic Chemicals Div., St. Louis 1, Mo. is described in a 4-page folder, Monsanto Technical Bulletin 0-87. The additive, besides inhibiting progressive polymerization of unstable elements in fuel oil, substantially reduces deposition of sludge on burner parts and by effective rust inhibition largely eliminates entrained rust at the fuel oil burner. It also protects handling and storage equipment from rusting due to occluded or dissolved water in the fuel or to condensation in tanks. Insoluble in water, it is not subject to depletion by extraction or reaction with water.

Magnaflux, a periodical issued by Magnaflux Corp., 7300 West Lawrence Ave., Chicago 31, Ill. describes and illustrates the non-destructive testing devices made by the company.

Spec-Flo Company, 720 Polk Ave., Houston, Texas, has developed Powermastic, a portable heater electrically fueled for viscous materials. The Power-

mastic 600-CX, with explosion proof construction, is designed to operate at an average fluid pressure of about 600 psi, plus an added safety factor. Volumes up to 100 gph may be handled. Heavy asphaltum and mastics after heating in the unit may be sprayed efficiently in cold weather. Savings in air pressure and greatly improved application are claimed.

Viscometran, an instrument which continuously records viscosities of materials in process is available from Brookfield Engineering Laboratories, Stoughton, Mass. It handles a wide variety of materials.

Unichrome Bright Nickel process is available now to the United States plating industry. Manufacturers report it provides a superior base for chromium plating, and is more efficient than other nickel solutions and gives a brilliant coating providing good protection of the basis metal against corrosion. Unichrome, Inc., 100 East 42nd St., New York 17, N. Y. will supply additional information on request.

Metal-Ceramic LT-1 thermocouple wells are resistant to air oxidation and combustion gases at high temperature, as well as to attack from molten steel and slag, reports The Bristol Co., Waterbury 20, Conn.

Donegal DC-50, a hardenable cast stainless steel with essentially the same characteristics as Armco 17-4 PH hardenable stainless alloy previously available in wrought form only is being produced by Donegal Manufacturing Co., Marietta, Pa.

Bassons Industries Corp., 1432 West Farms Road, Bronx 60, N. Y. has developed portable units which make possible on-the-site fabrication of glass laminated polyester pipes, containers and other hollow forms. Raw material and apparatus for centrifugally casting the shapes are taken to the site on trailers. Pipe in diameters from 6 to 60 inches or more can be produced economically, manufacturers say.

W. S. Dickey Clay Manufacturing Co., opened December 18 its \$2,600,000 clay sewer pipe plant at 5721 First St., Meridian, Miss. The plant makes pipe from 4 to 36 inches in diameter, vitrified wall coping, flue lining, drain tile and other clay products.

Glass-Based enamel developed jointly by Battelle Memorial Institute, Columbus, Ohio and Barrows Porcelain Enamel Co., Cincinnati, Ohio has materially extended the life of iron and steel equipment exposed to hot liquids, gases and corrosive chemicals at temperatures up to 1400 degrees F. Service life of iron or steel pipes was markedly increased in tests involving molten aluminum.

Molded Teflon O-rings are being made by Sparta Heat Treat Company's Plastic Division, East Sparta, Ohio. Inquiries as to sizes and specifications are invited.

APM (aluminum powder metallurgy) metal is being rolled in sheets by Alcoa. Application of the sheet for heat shields and other high temperature applications is predicted. Air valves from APM ex-

trusions are operating successfully at 700 degrees F on jet engine compressors.

Gordon and E. P. Doremus and Al Richey, all of Cathodic Protection Service, Houston participated in a television show December 10 at Houston. The 15-minute show was devoted to an explanation and demonstration of some of the aspects of equipment used in cathodic protection. The show is one of a series sponsored by the Houston Section of the American Chemical Society.

Vapor and Weather Barriers for Low Temperature Insulation, an illustrated 80-page book shows the technique of applying a vapor seal over thermal insulation. It was written and published by the Insul-Mastic Corp. of America, 1141 Oliver Bldg., Pittsburgh 22, Pa.

Binks AO-120 Extractor traps oil, water, rust and other foreign particles in air lines and prevents them from reaching spray guns.

Dynapump, made of stainless steel by Fostoria Pressed Steel Corp., Fostoria, Ohio, is designed for fresh or closed water circulating systems. It has no shaft seal or motor bearings requiring service.

Harvey Aluminum, Torrance, Calif., has announced the perfection of hot extrusion of alloy steel shapes. The firm is using the process to make parts for fighter aircraft. The process was made possible by the development of a superior die material and perfection of a more effective lubricant to protect dies surfaces from the molten steel. Extrusion saves money by eliminating expensive machine milling and by savings of materials and time in manufacture.

CATHODIC PROTECTION

- SURVEYS
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- MATERIALS

We engineer and install magnesium anode and rectifier installations. We handle standard materials—rectifiers, anodes, instruments and insulation materials.

Assured protection for pipe lines, offshore platforms, refinery and gasoline plant lines, municipal systems, barges.

**Everything
for
Anything !**

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**CORROSION
RECTIFYING CO.**

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Lapel Pins



Approx.
Size

Approximately 7/16 inches high, gold, inlaid with bright red enamel background to "NACE" and deep blue enamel background to words "CORROSION CONTROL." Ruby center.

For Association Members Only

\$10

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A. B. Campbell, Executive Secretary

**NATIONAL ASSOCIATION OF
CORROSION ENGINEERS**

1061 M & M Bldg., Houston 2, Texas

PERSONALS

J. J. Meany has been appointed vice-president of A. V. Smith Engineering Co., Inc., Ardmore, Pa.

Charles A. Bigelow, vice-president and director of Stone and Webster Engineering Corp. retired December 31 after more than 45 years service. **N. M. Floyd** took over management of the company's San Francisco office and **W. L. Sheets** of the Los Angeles office January 1. Mr. Sheets also was named general superintendent of the company's Western area.

Earle A. Channer has been named general sales manager of the H. M. Harper Company, Morton Grove, Ill. He joined Harper in 1939.

James H. Giles, Jr. has been appointed research fellow of the Porcelain Enamel Institute at the National Bureau of Standards, Washington, D. C.

Robert K. Beck has been elected president of Apex Smelting Company, Chicago.

Robert M. Moore has been elected vice president—sales of Pittsburghs Coke and Chemical Co., Pittsburgh. He has been with the company since 1942 and has been general manager—sales for the last seven years.

Lance H. Cooper of London, chairman of the Mond Nickel Co., Ltd. has been elected a vice-president of the International Nickel Co. of Canada, Ltd.

L. P. Schaefer, head of the engineering department of The Hinchman Corp., Detroit, has been appointed secretary of the company.

Paul Cecil, engineer in charge of research and development for Seapocel Enamels, Inc. has been elected president of the Eastern Enamelers Club.

Roy W. Davis has been appointed sales manager, Paints and Emulsions Dept., The Philip Carey Mfg. Co., Cincinnati.

Thomas L. Vance has been named sales representative for Southern California, Nevada and Arizona by Dresser Manufacturing Division, Bradford, Pa. He will have headquarters at Los Angeles.

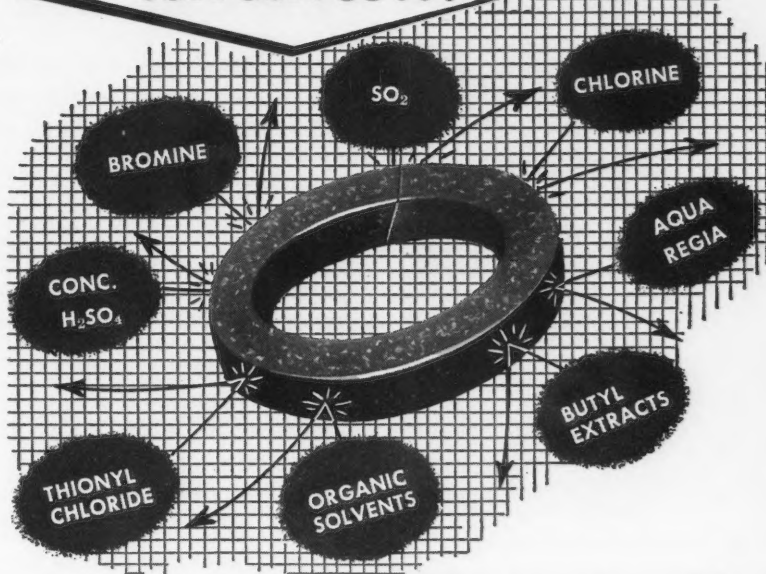
Bart C. Dickey has been appointed Process Development Engineer in the production department of Acheson Colloids Co., Port Huron, Mich.

Charles J. Kentler, Jr., 11 Rodgers Drive, Pittsburgh has been named consultant for the Rockwell Manufacturing Company meter and valve division. He is manager of refinery and chemical sales.

Henry W. Adams has joined the MW Protective Coatings Division of Metalweld as a sales engineer.

Arne Lovendahl has been appointed manager of the Philadelphia area office of Combustion Control Corp., Boston, Mass., manufacturers of Fireye Flame Failure Safeguards.

If you pump these corrosives...

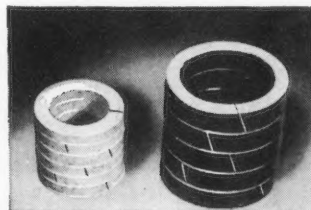


Get months of Trouble-Free service with CHEMPRO TEFLON PACKINGS

If your pumps and valves handle highly corrosive industrial chemicals, CHEMPRO TEFLON PACKINGS will drastically cut packing replacement and maintenance costs. CHEMPRO Packings last for many months under corrosive conditions which make ordinary packings useless in days or even hours. They stop leakage by providing a tight seal at only slight gland pressure, and their very low coefficient of friction often makes lubrication unnecessary.

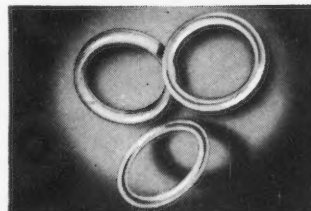
TEFLON* PLASTIC STUFFING BOX PACKING

Ideal for either centrifugal or reciprocating pumps operating at speeds up to 3600 R.P.M. handling corrosives at temperatures from -118° F. to 525° F. Style No. 101 composed of 94% shredded Teflon and chemically inert graphite as a friction reducer. Style No. 201 same as No. 101 except that mica is used as friction reducer. Both styles made to fit every size stuffing box on standard process equipment.



TEFLON V-TYPE PACKINGS

For reciprocating pumps and hand, air and motor operated valves handling corrosive materials. Lips of very sensitive pressure rings expand proportionately to increased operating pressure thereby preventing leakage. Suitable for temperatures from -150° F. to 550° F. Unsuitable for centrifugal or rotary pumps. Supplied in bulk or in complete sets to fit specific stuffing boxes.



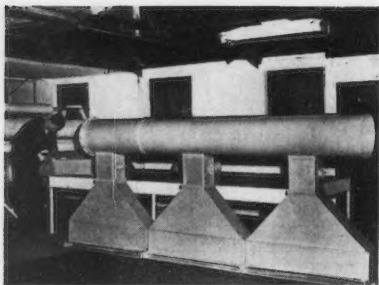
Chemical & Power Products engineers are packing and gasket specialists with complete fabricating facilities to meet your specific requirements. Write for our complete Teflon Packing and Gasket Catalog.



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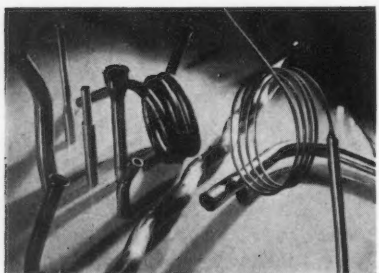
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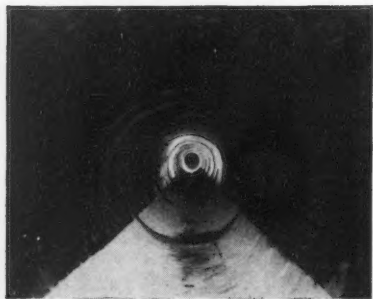
Polyester laminate fabrications



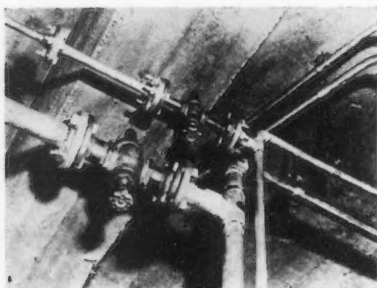
High temperature ceramics



Small gauge alloy tubing



Linings and coatings for pipe



Corrosion-resistant plumbing

A Magazine Exclusively for the Corrosion Market

Read by over 4700 NACE members
and 1300 non-members
ALL interested in corrosion

Illustrated are a few of the many kinds of materials and applications that interest readers of CORROSION magazine. If you are developing or selling a product with anti-corrosion applications you will find no better audience than CORROSION'S 6000 monthly readers.

There are two pages of editorial material for each page of advertising in CORROSION. Most of the editorial material in CORROSION has long-time reference value, giving equally long life for your advertising. At modest cost you can make your products, processes or services known to CORROSION readers seven out of ten of whom have some influence on purchases.

Write for copies of media sheets below which tell you how many readers CORROSION has, where they are and what they do.

Media
Sheet
Number

- 5 Corrosion Readership in the Chemical Industry
- 6 Corrosion Readership in the Gas Industry
- 7 Corrosion Readership in the Petroleum Industry
- 8 Corrosion Readers Interested in Water Supply
- 9 Corrosion Readership Interested in Coatings
- 10 National Industrial Advertisers' Association Outline, 1953.
- 11 Nature and Importance of Work Done by Corrosion Readers

Corrosion

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Tenth Annual Conference and Exhibition Section



F. L. WHITNEY, JR.
Chairman, Technical Program Committee,
Tenth Annual NACE Conference and Exhibition.



O. E. MURRAY
Exhibits Chairman, Tenth Annual NACE
Conference and Exhibition.

Technical Sessions, Committee Meetings, Big Exhibition Set

Forty-one technical papers in 12 symposia, two round table sessions, group discussions, educational lectures and other features comprise the technical program arranged for presentation at Kansas City March 15-19. All technical sessions, including committee meetings, with a possible few exceptions, will be held at Kansas City Municipal Auditorium.

The technical program, which with the technical committee meetings forms the meat of the 5-day conference, was arranged under direction of F. L. Whitney, Jr., Monsanto Chemical Company, St. Louis, chairman and H. L. Bilhartz, Atlantic Refining Co., Dallas, co-chairman. H. W. Schmidt, The Dow Chemical Company, Midland Mich., has been active in arranging the schedule of technical committee meetings.

Harry K. Phipps, Socony-Vacuum Oil Co., Inc., Wichita, Kan. is general chairman of the conference. O. E. Murray, Midwestern Engine & Equipment Co., Tulsa, Okla. is exhibits chairman. C. C. Keane, Great Lakes Pipe Line Co., Kansas City, Mo. is local arrangements committee chairman.

Technical Committee Meetings

The association's technical committees will meet all day Monday, March 15, opening day of the conference. Usually additional meetings or continuations of meetings are held during the remainder of the week. The meetings of the technical committees will be especially important this year because of the reorganization scheduled to be effective with the end of the conference whereby the arrangement of the various groups is changed.

The association's standing committees usually meet during the week of the conference and the executive committee or board of directors has two sessions, one on the Sunday preceding the opening day of the meeting and the second on the last day of the meetings.

Exhibition is Extensive

The list of exhibitors indicates that an extensive variety of corrosion control materials and processes will be on view. Not only is the exhibition expected to be larger than any previously held by the association, but the present indications are that the information made available will be equally increased. Morning technical sessions close at 11:30 and evening sessions open at 2, the interval between being provided for visiting the exhibition.

Serious attention to exhibits by registrants at NACE conferences has been reported by exhibitors. There is every reason to believe 1954 exhibitors will have the same experience.

Round Table Sessions

The General Corrosion Problems and Pipe Line and Underground Corrosion round tables are expected to draw their usual interested audiences. These sessions give registrants an opportunity

(Continued on Page 22)

Kansas City Conference to be Milestone In Progress of NACE, Plans Indicate

Few present on May 7, 1946 when registration for the Second Annual NACE Conference and Exhibition opened at Kansas City's Municipal Auditorium would have predicted what will take place at the association's Tenth Annual Conference and Exhibition opening next March 15. Who then could have foreseen that the number in attendance at the 1954 Conference would be three times the number of active NACE members in 1946? Who would have predicted an exhibition the size of the 1954 exhibition or the schedule of technical committee meetings extending from Monday through Friday?

The Kansas City 1946 program included 35 papers in two days of technical sessions. The first day of the session was devoted principally to association business and to meetings of standing committees. Two papers of general nature were given during the afternoon of the first day.

Officers at the 1946 meeting were Russell A. Brannon, president (now NACE treasurer); F. J. McElhatton was vice-president and O. C. Mudd, treasurer. Names of directors are all familiar, because, with few exceptions they have continued active in association affairs since. Among the directors were G. R. Olson, Guy Corfield, Robert Pope, Walter F. Rogers, Lyle R. Shepard, L. A. Baldwin, Robert M. Mears, H. R. Britton, George B. McComb, and F. L. LaQue.

Registration at the 1946 meeting was over 500.

There were 53 booths at the exhibition.

More Than Size Changed

NACE's progress since that meeting will be emphasized not only by differences in size and volume, but also by the

fact the technical interests of the association's expanded membership have developed a much more complex program. Added emphasis on high temperatures, chemicals and on economic considerations evidence progress in thinking on corrosion matters. Technical committee meetings will include a wide variety of subject matter, much of it particularized from the broad inquiries first engaging the attention of the association's members.

One of the principal achievements of the 1946 meeting, at a session presided over by F. L. LaQue, was the first steps leading to development of the Inter Society Corrosion Committee. This group, now numbering representatives from 36 technical and trade organizations, is working toward the fuller and quicker exchange of information on corrosion problems among its members so duplicated effort will be avoided.

More than two months of the association's tenth year will have passed by the time the Kansas City 1954 conference opens. It is confidently expected that the association's membership by that time will number in excess of 4600.

NACE Annual General Business Meeting Set

The annual general business meeting of the National Association of Corrosion Engineers will be held from 9 to 10 am on Tuesday, March 16 in the Kansas City Auditorium Little Theater. At this meeting usually are presented the reports of the standing committees and statements by the officers of the association on their activities during the year.

Corrosion Principles Symposium



Beck



Fontana



Godard



Harwood

About the Authors

FRANKLIN H. BECK—Assistant Director of the Corrosion Research Laboratories at The Ohio State University, Engineering Experiment Station. Dr. Beck received his BS in Metallurgical Engineering from the Pennsylvania State College and did his graduate work for an MS and PhD in Metallurgy at the Ohio State University under the supervision of Prof. M. G. Fontana. His graduate work was concerned with corrosion and passivation studies of 18-8 stainless steel. He was employed by the E. I. du Pont de Nemours & Company for two years before entering the Graduate School at Ohio State.

MARS G. FONTANA—Professor and chairman, Department of Metallurgy and Director of the Corrosion Research Laboratory at The Ohio State University, Columbus. He is a frequent contributor of technical material on corrosion, editor of a corrosion section of a technical magazine, a consultant on corrosion matters and otherwise active in corrosion mitigation work besides being in demand as an instructor in corrosion courses. He is past president of the National Association of Corrosion Engineers and a member of many other technical organizations.

HUGH P. GODARD—Since 1945 when he joined Aluminium Laboratories, Ltd., Kingston, Ont., his main interest has been research on the corrosion behavior of aluminum, on which he has published several papers. Active on technical committees on corrosion in Canada and the United States, he is presently chairman of the Inter Society Corrosion Committee, and a member of the board of directors of the National Association of Corrosion Engineers. He was active in the recent formation of NACE's Canadian Regional Division and is immediate past chairman of the Gordon Research Conference on Corrosion of the American Association for the Advancement of Science. He holds a PhD in industrial and cellulose chemistry from McGill University and a master's degree in chemical engineering from the University of British Columbia. Before joining Aluminium Laboratories, Ltd., he worked as an industrial chemist in the fields of wood pulp, copper, gold mining and explosives.

J. J. HARWOOD—Head of the Metallurgy Branch of the Office of Naval Research, Navy Dept., Washington, D. C., he is chairman of the Subcommittee on Corrosion Definitions and Terminology of the Inter Society Corrosion Committee, a member of the National Association of Corrosion Engineers' editorial review subcommittee and of several other professional societies. He holds a BS from the College of the City of New York and an MS from University of Maryland. With the navy since 1941, he has been with the Office of Naval Research since 1946.



Priest



Williams

DAVID K. PRIEST—Now associated with the Research Laboratory of the Pfaunder Co., Rochester, N. Y., he was Research Associate in the Ohio State University Research Foundation specializing in corrosion research for two years beginning in 1951 while completing requirements for his PhD. A native of Ohio, he attended Otterbein College, Westerville, Ohio, and Ohio State University, receiving Bachelor of Metallurgical Engineering and Master of Science degrees from that school.

ROBERT D. WILLIAMS—He has been with the Chemical Metallurgy Division, Aluminum Research Laboratories, Aluminum Company of America, since 1949. His work is associated with fundamental research on electrochemical mechanisms involved in corrosion processes. His undergraduate work was done at University of Utah and University of Oregon and his PhD was obtained from University of Oregon.

Stress Corrosion Is Topic of Three Papers In Principles Session

Principles involved in the phenomenon of stress corrosion will be explained and illustrated in the three items on the Corrosion Principles Symposium to be given beginning at 10 am March 16 at Kansas City on the second day of the Tenth Annual NACE Conference. Two of the items are sound films, both recently completed.

H. P. Godard, Aluminium Laboratories, Ltd., Kingston, Ont. and T. P. May, The International Nickel Co., Inc., New York are respectively chairman and co-chairman of the symposium.

First item on the program is a paper by Dr. Godard and J. J. Harwood of the Office of Naval Research titled "Some Remarks on Stress Corrosion Testing." The films are Factors in Stress Corrosion Cracking Revealed by Cinema photography, produced by the Chemical Metallurgy Division, Alumi-

num Research Laboratories, Aluminum Company of America; and A Study of Stress Corrosion, produced under the technical direction of D. K. Priest, The Pfaunder Co., Rochester, N. Y. with technical advisors H. F. Beck and M. G. Fontana of Ohio State University, Columbus.

Abstract

Some Remarks on Stress Corrosion Testing. By H. P. Godard and J. J. Harwood.

A brief introduction to the subjects of stress corrosion and stress corrosion cracking and to the purpose of laboratory stress corrosion testing is given. General testing principles are summarized and the more commonly used jigs are illustrated, with emphasis on the Loose and Barbican spring-loaded portable jig. Experience of the authors with this and with Alcoa constant-strain jig is described. Some general principles on stress corrosion testing techniques and the interpretation of results is presented.

Abstract

Factors in Stress Corrosion Cracking Revealed by Cinemaphotography.

A film showing the creation of stress corrosion cracks is shown. Discussion by R. D. Williams.

Abstract

A Study of Stress Corrosion.

The motion picture illustrates the effect of seat treatment and cathodic protection on the stress corrosion of the magnesium-6% aluminum-1% zinc-0.2% manganese alloy in a 3% K₂CrO₄ solution at room temperature. The photography was done at 20 and 80 diameters magnification and the action speed of cracking is shown and no "stop-motion" photography employed. In small grained specimens intergranular stress corrosion cracking is shown to result from furnace cooling of the alloy, while transgranular stress corrosion cracking results upon quenching from the solution temperature.

Large grained specimens at 80 diameters showed much local plastic deformation accompanies transgranular stress corrosion. This deformation is seen as a "shock wave" propagated in advance of the tip of the crack. Dependence of direction of transgranular cracks on crystallographic orientation is also shown. Transgranular cracking is shown to take place parallel to slip lines and therefore along the basal plane of the alloy.

Application of cathodic protection successfully stops both transgranular and intergranular stress corrosion cracking. Stopping and re-starting the crack by application and removal of cathodic protection is pictured. An animation sequence illustrates principles of cathodic protection.

Technical Committees To Be Reorganized

A principal activity of the NACE technical committees during the Kansas City 10th Annual Conference and Exhibition will be planning the reorganization of the groups into six main subdivisions instead of the 19 currently existing. In every instance existing committees will remain the same except for changes in title and position in the committee structure.



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Nondestructive Testing Symposium



Dehn



Evans



Headrick



Prange



Price



Schmidt



Warren

About the Authors

GEORGE L. C. DEHN—Now Southwestern Territory Branch Manager for Magnaflux Corp., with headquarters at Dallas, he joined Magnaflux in 1940 at Chicago. After some time in the research and engineering department he spent several years in the New York territory where he helped develop his company's first production inspection technique on jet engines. Since coming to Dallas in 1946 most of his time has been spent developing technique and applying methods of nondestructive testing to petroleum production, refining and transportation equipment. He graduated from James Milliken University, Decatur, Ill., with a degree in mechanical engineering. He is author of several papers and a member of a number of technical societies, including NACE.

DWIGHT J. EVANS—He established Engineering Test Services, Inc., at Tulsa early in 1950. This company is engaged in ultrasonic testing, equipment sales and experimental stress analysis. He holds a BSEE (1938) from University of Kansas. After employment in the Engineering Test Division of Phillips Petroleum Co., Bartlesville, after graduation, he spent three years in the navy as radar officer and returned to Phillips. In 1948 he joined Branson Instruments, Inc., Stamford, Conn., and left them in April, 1950, to form his own company.

J. F. HEADRICK—Borger District Supervisor, Test Division, Engineering Dept., Phillips Petroleum Company, he has worked on plant design, concrete problems, material examination and field inspection. He holds a BS in civil engineering from University of Kansas, 1939.

F. A. PRANGE—Since 1941 he has been working on metallurgical and corrosion problems encountered in the refining of oil and manufacture of petrochemicals in the Test Division, Engineering Department, Phillips Petroleum Company, Bartlesville, Okla. He received a BS in chemical engineering from Purdue University in 1940 and an MS in metallurgical engineering in 1941 and joined Phillips after graduation.

ROBERT W. PRICE—Since September, 1951, he has been a member of the Materials Engineering Service of Dow Chemical Company, Midland, Mich. He was graduated from University of Michigan in 1951 with a BSME.

H. W. SCHMIDT—For 22 years he has been working on metallurgical and corrosion problems at the Midland, Mich., plant of the Dow Chemical Company. With a BS and MS in chemical engineering from Michigan State College (1923 and 1925) he was employed in the laboratory of the Jackson Steel Products Division, General Motors Corp., until 1929. For the next two years he was associated with the Chromium Plating Corporation, after which, in 1931, he joined Dow. He is currently supervisor of Dow's Materials Engineering Department. Mr. Schmidt is chairman of the NACE Technical Practices Committee, active in technical committee work and in other phases of the activities of NACE. He is also a member of AWS, ASM and The Electrochemical Society.

WILLIAM J. WARREN—He has been with the Mechanical and Electrical Engineering Department of the Emeryville Research Center of Shell Development Company since August, 1951. He holds a BS in electrical engineering from University of Santa Clara and an MS and PhD in electrical engineering from University of Illinois. He has been a teacher of electrical engineering, test engineer with General Electric Company, Schenectady, N. Y., development engineer with Hewlett-Packard, Palo Alto, Cal., and has done private consulting work.

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Chemical, Marine, Oil Industries Are Covered by Papers

Besides surveying the use of non-destructive testing methods in the chemical, marine and petroleum industries, the five papers in the Non-Destructive Testing Symposium include data on the Probolog and the technique of testing for corrosion cracking by nondestructive means. Techniques for testing the soundness or thickness of structural materials from one side have developed rapidly in the past several years. These tests have been increasingly necessary and important as a result of the added corrosiveness, temperatures and pressures which characterize modern industrial processes. In addition to the vital safety information these tests provide, they also permit an evaluation of possible product contamination and check on the effectiveness of control measures.

The five papers to be presented are

Abstract

Non-Destructive Thickness Measurement in the Marine Industry. By Dwight J. Evans.

Corrosive deterioration of plates in many Type M-2 oil tankers built during war years and in many older vessels has reached serious proportions. Complete thickness surveys of internal bulkhead and hull plates by means of a non-destructive measuring device called the Audigage have been accomplished at a saving of about 80 percent of the cost of drilling and measuring each plate.

Readings obtained with this instrument are approved by the American Bureau of Shipping provided the local surveyor is convinced of the integrity and ability of the engineer making the survey. Accuracies required in surveys with sound equipment are on the order of plus or minus 0.005-inch, and at least one shipping company has proved measurements by drilling and caliper can not be made with an equivalent order of accuracy.

Abstract

Probolog, an Application of Eddy Current Techniques to Non-Destructive Testing. By Warren J. William.

A brief description of the methods used for field inspection of equipment are given. Experience with these methods is discussed and ultrasonic and gamma radiation methods are considered from the standpoint of thickness determination are considered.

Abstract

Non-Destructive Testing in the Chemical Industry. By H. W. Schmidt and R. W. Price.

Abstract

Probolog, an Application of Eddy Current Techniques to Non-Destructive Testing. By William J. Warren.

A physical picture of eddy currents and their effects on the parent magnetic field is reviewed. Basic configuration of the Probolog probe and its electrical relation to the eddy current paths in tubing under test are considered. Probation in detecting corrosion is ex-

(Continued on Page 22)

1

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2

cement



3

assemble



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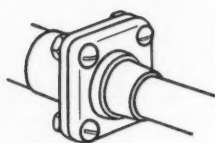
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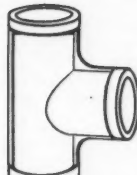
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Cost of Corrosion Symposium



Alquist



Larrabee



Wachter

About the Authors

F. N. ALQUIST—Research Chemist, Organic Research Division, the Dow Chemical Company, Midland, Mich. Dr. Alquist, formerly chairman of the NACE Editorial Review Sub-Committee, is chairman of the NACE Technical Practices Committee 13 on Annual Losses Due to Corrosion. Long active in investigation of corrosion problems, he holds a PhD from Purdue and has been instructor at several universities. He has contributed many articles to technical journals and is a member of several scientific organizations.

C. P. LARRABEE—Research Associate in the Research Laboratory, United States Steel Corporation, he is a graduate of the University of Maine. His corrosion work extends over more than 18 years and covers inquiries into the corrosion resistance of low alloy steels, among other things. A frequent contributor of technical material on corrosion, he is a director of the National Association of Corrosion Engineers, having been a member since 1944.

AARON WACHTER—Manager of the Corrosion Department of Shell Development Company, Emeryville, Cal., Dr. Wachter has been vice-president of NACE during the past year. He was a member of the NACE board of directors before his election to the vice-presidency. He has been active in organizing new subdivisions of NACE on the Pacific Coast, in the affairs of several of the association's technical practices committees and has been chairman of the 1950 Conference Technical Program Committee and of several symposia presented at NACE national meetings.

Economic Aspects of Corrosion Control Are Considered in Papers

The economic aspects of corrosion losses and control measures are considered in three papers to be given in the Cost of Corrosion Symposium. F. N. Alquist, The Dow Chemical Co., Midland, Mich. and H. H. Uhlig, Massachusetts Institute of Technology are chairman and co-chairman respectively.

Some hopeful signs that the use of materials designed to give the lowest overall cost per year is growing are seen by one author. Another paper explains how one company approached the problem of reducing its \$20,000,000 annual corrosion loss. The third paper deals with the seldom-explored topic of business costs of corrosion.

Abstract Cost of Corrosion in the Chemical Industry. By F. N. Alquist.

Estimating the yearly corrosion loss of one chemical company to corrosion at \$20,000,000, the author enumerates the several avenues adopted in efforts to reduce it. The techniques include all types of protective coatings, inhibitors, cathodic protection, corrosion-resistant metals and alloys and non-metallic substitutes and dehumidifying, dehydrating and deaerating practices.

Abstract Lessen Atmospheric Corrosion Costs Through Testing Programs. By C. P. Larrabee.

The author estimates the annual loss resulting from atmospheric corrosion to be about \$2,000,000,000. Data are presented showing how losses are being decreased markedly by applying results of testing programs. Rack and service test data are used. The author finds the use of materials giving the lowest over-all cost per year is increasing.

Relation of Corrosion to Business Costs. By Aaron Wachter.

Chemical, Marine—

(Continued From Page 20)

pressed in terms of voltages corresponding to simulated effects in the tubing. These voltages appear at the detector diagonals of the Wheatstone bridge of which the probe is a part and are amplified, detected and recorded on a strip chart. Controls in the bridge circuit permit some adjustment for accommodating the voltages to various non-magnetic materials.

Some special applications of the Probolog principle to other non-destructive testing operations are described briefly.

Abstract Non-Destructive Testing in the Petroleum Industry. By F. A. Prange and J. F. Headrick.

Non-destructive testing in the petroleum industry starts at the well and is carried through the refineries and gasoline plants. Visual examination is the most widely used testing method, while simple mechanical methods involving pit depth gauges and calipers are used frequently.

Of the more specialized methods, tubing caliper inspection and Audigage measurements are most widely used. Remote indicating caliper devices, the Penetron and magnetic particle testing are also employed to a considerable

extent. Some highly specialized instruments also are used occasionally.

Abstract Prevent Corrosion Failures with Non-Destructive Testing. By George L. C. Dehn.

Increasing stress levels brought about by process and design changes in modern industrial equipment, new alloys and lower safety factors are increasing corrosion and corrosion fatigue. Non-destructive testing is a means of selecting sound material.

Frequent inspection and testing by such methods as Magnaflex, Zygl, Spotchek and others give critical information without affecting materials or interrupting their use unduly.

Suitable records of testing procedures and results should be kept to permit forecasting of fatigue or corrosion failures so corrective measures may be taken or design changes made to avoid extensive repairs.

Technical Sessions—

(Continued from Page 17)

to ask questions and discuss mutual problems.

The Pipe Line Group Discussions, consisting of eight groups of not more than 40 each probably will enjoy the same popularity they did at the Chicago 1953 conference where they were first held. These small groups provide a forum for questions and answers at any level on the subject matter. Experienced engineers will attend to assist with answer when necessary.

Educational Lectures

Three educational lectures are scheduled, each from 4:30 to 5:30 pm the second, third and fourth days of the meeting. At Chicago in March 1953, when this feature was introduced to NACE Conferences, the lectures had standing room only audiences. They are expected to be equally popular this year.

Two films on stress corrosion will be shown and discussed as part of the Corrosion Principles Symposium.

Discussions Collected At Meetings for Publication in Corrosion

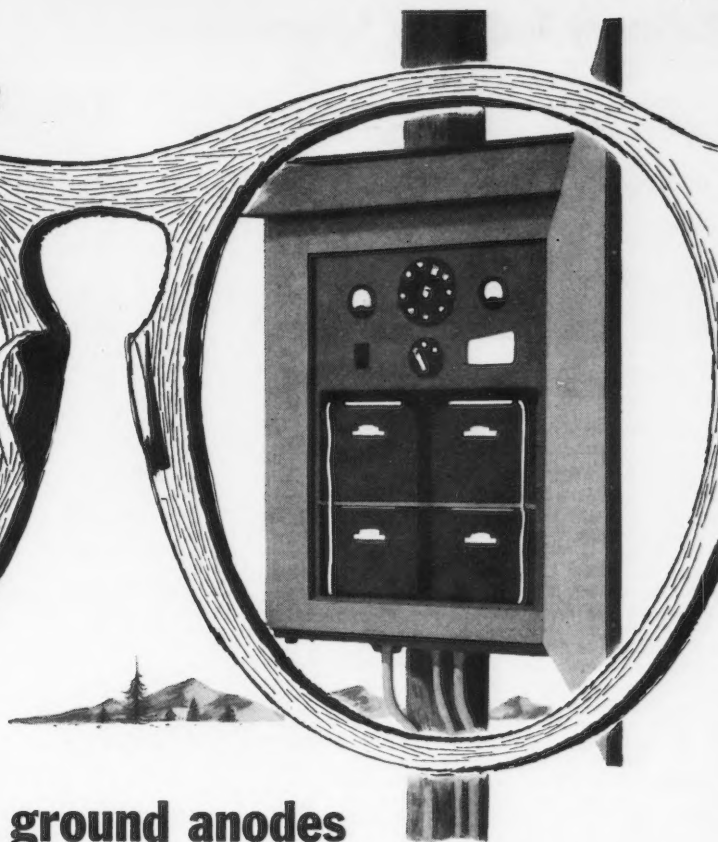
An effort is made at all national and at some regional meetings of the National Association of Corrosion Engineers to secure written copies of discussions of technical papers. Printed forms are provided the use of discussors. These forms may contain a brief summary of what was said which permits the association to obtain a formal written version later.

Discussions of technical material presented at NACE meetings or published in CORROSION are solicited. Discussors are not required to use forms provided for the purpose but may submit their comments in any convenient form. The addition of illustrations, tables and other detailed substantiating data in discussions is welcomed.

Provisions will be made for soliciting and collecting discussions during and after technical sessions at Kansas City.

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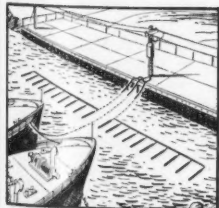
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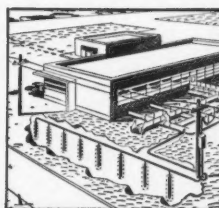
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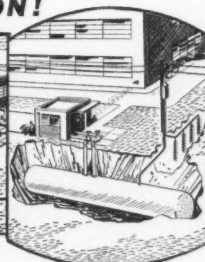
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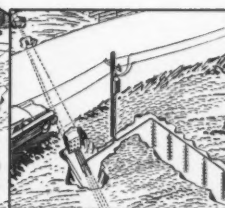
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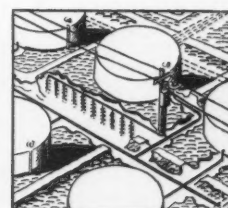
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Refinery Industry Symposium



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About the Authors

H. HOWARD BENNETT—He is corrosion engineer at the Paulsboro, N. J., refinery of Socony-Vacuum Oil Co., Inc. With a degree in chemical engineering from Drexel Institute of Technology, he has worked for Socony-Vacuum in its Plant Control Laboratories, Operating Department, Research and Development Laboratories and Engineering Department.

V. J. GROTH—He has been engaged in engineering development work with Standard Oil Co. (Indiana) at Whiting, Indiana since 1950. A graduate of Michigan State College in 1948 with a BS in chemical engineering, he joined his present employer on graduation.

RAYMOND J. HAFSTEN—Presently head engineer in the Engineering Division Development Department of Standard Oil Company (Indiana), Whiting, Ind., he was graduated from the University of Alabama in 1937 with a BS in metallurgical engineering. He worked successively for United States Steel Research Laboratory, Kearny, N. J.; became chief metallurgist for the Fall River, Mass. plant of Firestone Steel Products Co. in 1941 and later engaged in research at Armour Research Foundation, Chicago.

RICHARD S. TRESEDER—A frequent contributor of technical material on corrosion and active in the NACE technical committees doing work in the petroleum field, he is with Shell Development Company, Emeryville, Cal. He has been engaged in corrosion investigations for more than 12 years and holds a BS in chemical engineering from University of Utah.

Three Papers and General Discussion Due in Symposium

Three papers to be followed by a discussion of individual problems in the refinery industry corrosion field are scheduled for the Refinery Industry Symposium. E. H. Tandy, Standard Oil Co. of Cal., El Segundo and F. M. Watkins, Sinclair Research Laboratories, Inc., Harvey, Ill. are respectively chairman and co-chairman of the symposium.

Papers cover consideration of corrosion problems in domestic fuel oil tanks, inhibitors in petroleum refining and corrosion from sulfuric acid. The discussion session is intended to provide a means of getting answers to questions on refinery corrosion by mutual exchange of information.

The papers scheduled are:

Abstract

Internal Corrosion of Domestic Fuel Oil Tanks. By R. Wieland and R. S. Treseder.

Failures of domestic fuel oil tanks by internal corrosion perforations of bottoms has been a troublesome problem. Primary cause is believed to be a small amount of water in tanks, but no satisfactory explanation has been available for the rapid localized attack that occurs sporadically.

Laboratory data presented show that very rapid penetration can result from localized rusting action by water if the surface of the steel is coated imperfectly. Examples of such imperfect coatings are mill-scale with breaks in the scale, thin sludge deposits and dirt collected in the bottom of the tank. No evidence was found for formation of acidity as a cause for accelerated attack.

Addition of a sodium nitrite mixture to the tanks has proved an effective means of preventing these corrosion failures. Supporting laboratory data are presented.

Abstract

High Molecular Weight Organic Corrosion Inhibitors in Petroleum Refining. By H. Howard Bennett.

A theory of the mechanism by which the high molecular weight organic corrosion inhibitors function to prevent corrosion and act as detergents is discussed. The use of test coupons and stream analysis as methods of determining effectiveness of inhibitors used in petroleum refining equipment is evaluated.

Several applications, some unique, in which inhibitors are used to solve corrosion problems in petroleum refining equipment are described. Certain of these applications have permitted economical use of carbon steel in place of critical alloys. A trial run on a crude distillation unit indicates a water-soluble type of inhibitor was effective in controlling corrosion at a low pH without the use of ammonia at a cost of less than \$.5 mil per barrel crude charge. When used on crude units with ammonia, cost of the same inhibitor has been from 0.1-0.3 mils per barrel of charge. In other applications savings realized by the use of inhibitors have justified their use as a result of lengthened equipment life, less down time for repairs and cleaning and improved operation.

Abstract

Corrosion of Refinery Equipment by Sulfuric Acid and Sulfuric Acid Sludges. By V. J. Groth and R. F. Hafsten.

High maintenance costs and many cor-

rosion problems result from the handling of large tonnages of sulfuric acid in refineries. Strong acid and strong acid sludges are handled in steel tanks while welded or riveted tanks lined with lead are required for weak acid or weak acid sludges.

At moderate temperatures strong acids may be handled in steel lines provided dilution by steam or other water sources does not occur. Red brass or lead pipes are needed for weak acid or weak acid sludges. Heating coils usually are made of brass or lead. Brass coils fail by corrosion and lead coils by rupture. Excessive pressure and steam hammer cause lead failures because of its low physical strength.

Steel pumps can be used for strong acids or sludges while brass pumps are needed to handle weak acids or sludges.

Slight corrosion of valve gates or seats will cause unsatisfactory service and, unlike tanks and lines, corrosion allowances cannot be provided on all valve parts, consequently alloy valves are economical in service handling strong and weak acids.

ASME Presents Seven Awards at Meeting

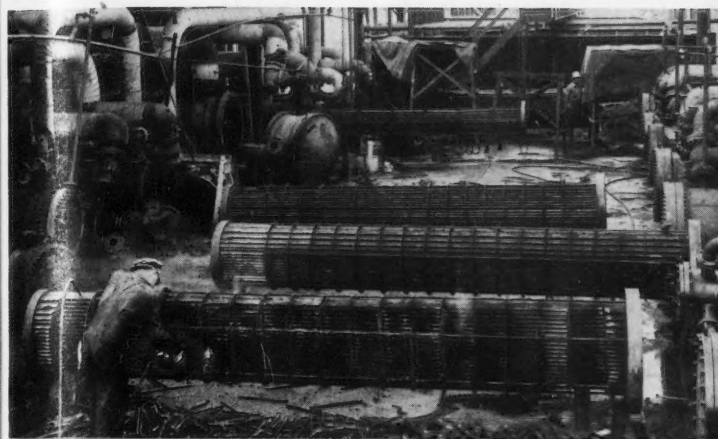
Seven industrialists and educators were presented with special awards for outstanding service in various engineering fields at the annual banquet of The American Society of Mechanical Engineers at the Society's annual banquet held in New York, December 2.

Award recipients were Crosby Field, president, Flakie Corp., Brooklyn, N. Y., who received the ASME medal; Alexander G. Christie, professor emeritus of mechanical engineering, the Johns Hopkins University, Baltimore, Md., who received the ASME Westinghouse award; Philip M. McKenna, president, Kennametal, Inc., Latrobe, Pa., who received the Holley medal; William H. McAdams, professor of chemical engineering, Massachusetts Institute of Technology, and Harvard University lecturer, who was given the Warner medal; Jefferson C. Falkner, manager, Electric Production Dept., Consolidated Edison Co., New York, who received the Melville medal; Thomas M. Lumly, president, Refinery Engineering Co., Tulsa who received the Richards award; and Merl Baker, director Kentucky Research Foundation, University of Kentucky, Lexington, who received the Phi Tau Sigma medal.

Mechanical engineers attending the annual convention heard two executives stress the importance of automation as a means of getting lower costs and greater production volumes. G. H. Gustat, superintendent, Industrial Engineering Division, Eastman Kodak Co., Rochester, N. Y. said that administration and supervision must be better both technically and in basic human understanding, to make automation work effectively.

In the opinion of Charles E. Knight, plant engineer of the Monsanto Chemical Co., plastics division, the new fully automatic factory will require a radical change in the form of business organization. Human effort and decision in production would be confined to the programming and line maintenance level, he said.

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Pipe Line Coatings Symposium

New Developments and Techniques in Pipe Line Coatings Scheduled for Discussions

New development and techniques in four principal types of pipe line coatings will be discussed during the Pipe Line Coatings Symposium at Kansas City. The program has A. D. Simpson, Jr., United Gas Corp., Houston and A. W. Peabody, Ebasco Services, Inc., New York City as chairman and co-chairman respectively.

The four principal coating areas and the discussion leader for each are listed below. Each discussion leader will open his part of the program with a brief discussion of the nature, properties and application techniques related to his topic. Questions and answers will then be solicited from the audience.

Asphalt Coatings—W. S. Stokes, Pipe Line Coating & Eng. Co., Huntington Park, Cal.

Coal Tar—R. G. Roberts, Barrett Division Allied Chemical & Dye Corp., Chicago.

Plastic Tapes and Coatings—R. B. Bender, Plastic Engineering and Sales Corp., Fort Worth, Texas.

Waxes—Wayne H. Schultz, Dearborn Chemical Co., Denver, Col.

BOOK REVIEWS

Administration Report for the Year 1952-53. Water Works, Bombay Municipal Corp. 8½ x 13 inches, 26 pages. 1953. Office of the Hydraulic Engineer, Improvement Trust Bldg., 7 Napier Road, Fort, Bombay, India.

The report describes the city's water system, gives supply statistics, lists major leaks, number of lineal feet of main painted, construction information, campaign against cattle trespassing and illustrates with topographic maps and with graphs various data on the operation of the water system.

Details are given on operation of a hospital, on the system's waste prevention branch which involves house-to-house canvasses to locate and repair leaky taps, on a public relations program on water conservation, as well as on numerous data related to staff numbers, pumpage, statements of short supply, and defects located on pipes and valves.

Fifty Years of Paint Testing. 6 x 9, 47 pages, paper cover. 1953. The American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Per copy\$1.25

This booklet is a collection of reports on paint testing by the members of ASTM Committee D-1. The separate subdivisions of the committee report on their history and achievements and indicate their routes of future inquiry. Topics covered by the subcommittees are: Drying oils, bituminous emulsions, volatile hydrocarbon solvents for organic protective coatings, accelerated tests, methods of chemical analysis of paint materials, varnish, optical properties, resins, exterior exposure testing on wood, shellac, pigment specifications, printing inks, flash point, physical properties of materials, cellulosic coatings and related materials, protection of iron

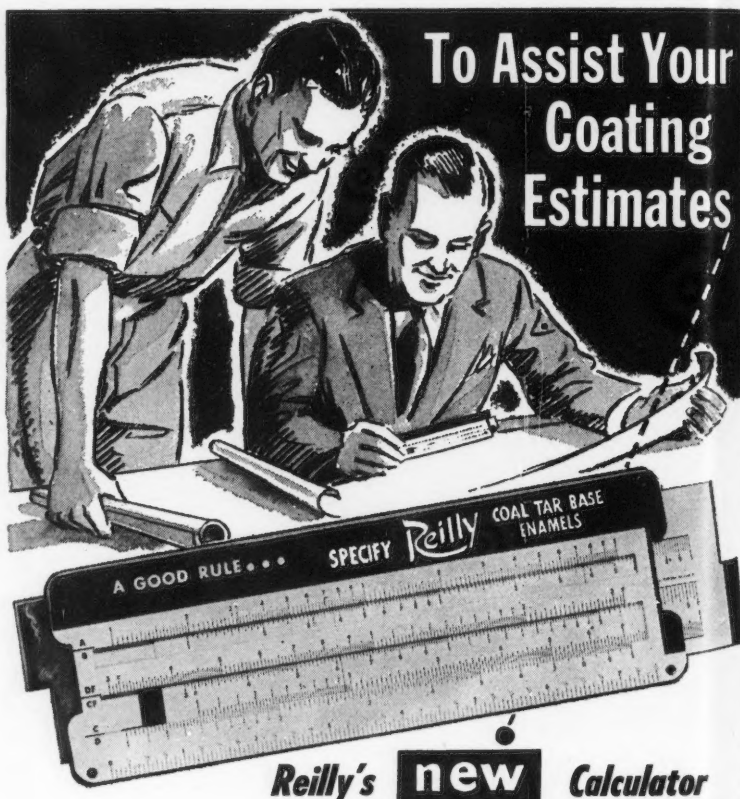
and steel. Some of the reports include extensive data.

The last report on the protection of iron and steel relates and illustrates with graphs and tables the committee's experience in a testing program designed to evaluate the treatment of steel with cold phosphate treatments. This work, initiated in 1937, resulted in accumula-

tion of data which indicated that performance of panels with mill scale intact was as good as that of panel sand-blasted before retreatment. Panels wire-brushed after rusting gave very short paint life under all conditions.

The committee is now investigating the economic aspects of repainting, seeking to determine when repainting will be best from a long-term cost standpoint. The subcommittee's work also has been broadened to include an investigation of preparation of aluminum and magnesium surfaces for painting. Another group is preparing 40 colored pictures showing the classification of ferrous surfaces for painting.

(Continued on Page 30)



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Mn	.15 Min.	.15 Min.	.15 Min.
Fe	.003 Max.	.003 Max.	.003 Max.
Ni	.003 Max.	.003 Max.	.002 Max.
Cu	.1 Max.	.05 Max.	.02 Max.
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Chemical Industry Symposium



Binger



Bish



Cataldi



Collins



Dravnieks



Fischlowitz



LaQue



Renshaw



Shepard

About the Authors

Photographs and biographies of F. H. Beck and M. G. Fontana, authors in this symposium, may be found on the page headed "Corrosion Principles Symposium" preceding.

W. W. BINGER has been with the Chemical Metallurgy Division, Aluminum Research Laboratories, Aluminum Company of America since 1943. He has been concerned chiefly with the development of applications of aluminum alloys in the chemical industries. During 1944 and 1945 while on leave from Alcoa he was associated with the Manhattan Project at both the University of Chicago and Oak Ridge, Tennessee. He was graduated from the University of Wisconsin in 1943 with a BS in chemical engineering.

PERRY R. BISH—Now employed in the Chemistry and Corrosion Section of Allegheny Ludlum Steel Corporation's Research Laboratory. He spent two years in the Chemical Corps., U. S. Army and is a 1950 graduate of Grove City College with a BS in chemical engineering. He is a member of the American Chemical Society.

HORACE A. CATALDI—When the work reported in the paper included in this symposium was done he was Assistant Project Engineer in the Engineering Research Dept., Standard Oil Company (Indiana) and engaged full time in corrosion research. He joined Standard Oil

in 1950. He is now in the Materials and Processes Laboratory, General Electric Company, Schenectady, N. Y. working on high temperature corrosion. He has a BS in chemical engineering from College of the City of New York (1940) and a PhD in chemical engineering from the University of Illinois in 1949. He was employed as a physicist by the Navy Department during the war and worked as a physical chemist and assistant department supervisor in electronics at Oak Ridge.

JAMES A. COLLINS—Since 1939 in the Engineering Department of E. I. du Pont de Nemours & Co., Inc. he has devoted full time to evaluation, selection and specification of materials of construction and the design, fabrication and installation of chemical process equipment. He holds a BS and MS in metallurgy from Case Institute of Technology and a PhD in metallurgy, Yale (1939). From 1934 to 1936 he taught and assisted with laboratory courses in metallurgy.

ANDREW DRAVNIKES—Senior Project Engineer in the Engineering Research Department at Standard Oil Company (Indiana) he holds a ChE degree from University of Latvia (1938) did advanced work there and at Marburg University, Germany and received a PhD from Illinois Institute of Technology in 1949. He has been instructor at the University of Latvia and technical director of a paint firm in that country as well as research associate with Illinois Institute of Technology. His work centers on paint technology, polarography, surface chemistry and the kinetics of corrosion processes, especially at elevated temperatures.

BERNARD FISCHLOWITZ—Technical director, Orchard Paper Company, St. Louis. He has been employed by Orchard Paper Company since 1932, first on a consulting basis and later as chemist and chief chemist. His work during the past five years has been devoted in large measure to developing the various aspects of vapor phase inhibitors, including laboratory and field testing, production problems in coating papers. He holds a BS and MS from Washington University.

F. L. LAQUE—Mr. LaQue's long time interest and activity in corrosion control matters have made him a familiar figure at most gatherings (Continued on Page 30)

Two Sessions Set for Chemical Industry's 8-Paper Program

The eight papers scheduled to be presented during the Chemical Industry Program at the NACE tenth Annual Conference and Exhibition at Kansas City have been divided into two sessions. The papers will cover a wide variety of subjects, evidence of the growing interest in the chemical industry in matters relating to corrosion control. E. G. Holmberg, Alloy Steel Products Co., Linden, N. J. is chairman of the symposium and W. B. DeLong, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del., is co-chairman.

Subjects range from evaluations of plastic materials of construction to measuring corrosion product. Covered also will be inhibitors, design considerations and two papers on metallurgical aspects.

The eight papers are:

Abstract

Use of Plastics as Materials of Construction in the Chemical Industry. By S. W. Shepard.

Plastics are taking an increasingly important place as materials of construction in the chemical and process industries. Their chemical resistance, ease of fabrication, absence of catalytic activity on chemical reactions and freedom from metallic or metallic compound contamination of products has made them irreplaceable. The excellent physical properties of some of the fiberglass reinforced plastics has widened the field of usefulness enormously.

Abstract

Corrosion and Erosion-Corrosion of Some Metals and Alloys by Strong Nitric Acid. By F. H. Beck, M. G. Fontana, J. F. Willging and J. P. Hirth.

Corrosion and erosion-corrosion resistance of several stainless steels and aluminum alloys in strong nitric acid in the temperature range from room temperature to 160 degrees F was investigated. In general the stainless steels show a marked increase in corrosion with increasing temperature. Galvanic couple systems of aluminum and stainless steel show the stainless steel to be protected by the aluminum, which acts as a sacrificial anode in strong nitric acid. Polarization studies on aluminum and stainless steel provide some interesting information concerning the corrosion behavior of the aluminum-stainless steel couple systems.

Erosion-corrosion tests show that the rate of attack on stainless steel decreases with increasing velocity of acid flow. The rate of attack on aluminum tends to increase with increasing velocity of acid flow. Experiments were conducted on rotating and stationary specimens in a system involving a flowing solution.

A detailed description is included of the equipment used for the polarization and erosion-corrosion studies.

Abstract

Industrial Application of a Method for Measuring Small Amounts of Corrosion Without Removal of Corrosion Products. By Andrew Dravnieks and Horace A. Cataldi.

The electrical resistance technique, de (Continued on Page 30)



News about COATINGS for METALS

Metallic Organic Decorative Protective

"Heavy" coatings deliver heavy duty protection

Plastisol usage for drum linings increasing

Drum manufacturers as well as drum reconditioners are beginning to make Unichrome plastisol-protection available to users of steel drums. And these users have begun to find the answers to better product packaging with less corrosion or contamination through these materials.

Also because of these heavy-duty linings, many newly developed products can be shipped in ordinary drums. In addition, they permit economical reuse of containers. Here's an interesting though accidental case to illustrate the point.

A producer of corrosive chemicals had several drums plastisol-lined for test. When research looked for the drums, they had disappeared. Later, they were found in the shipping department. They had been returned, inspected and re-shipped about 20 times. Regular lined drums had been good for only one to three trips.

Contact your supplier about lining your drums with Unichrome Series 4000 Drum Linings.

What a good "painting" program should do

The effectiveness of protective coatings used for corrosion control in processing plants can be measured by several obvious results of the program.

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- (2) Has it increased interval between repainting?
- (3) Has it maintained a better looking plant?

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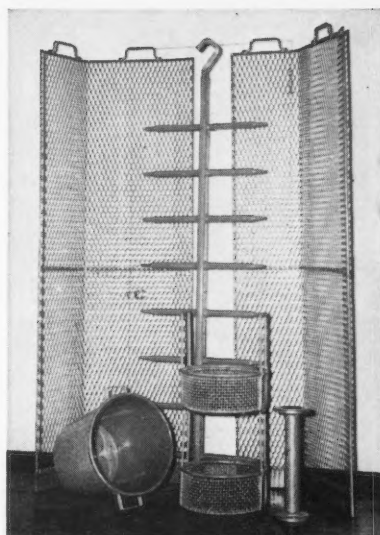
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- (1) They are highly chemical resistant. Produced from vinyl resins and plasticizers, Unichrome Plastisol Compounds display great resistance not only to acids and alkalis, but also to water, salts, oxidizing agents and many other corrosives.
- (2) They are resilient. While Unichrome Plastisol formulations can be modified to produce a coating in any range from soft to hard, the greatest number of applications seem to be in the elastic, rubbery range. In this state, Unichrome Plastisols can out-class rubbers on toughness, chemical inertness and economy for many applications. And unlike ordinary protective coatings, Unichrome Plastisols absorb abuse and impact without chipping.
- (3) Thick films can be produced. To guard against porosity in a coating and the possibility of accidental break-through, minimum film thicknesses are usually specified for protecting metals against strong corrosives. The thicker, the greater the protection. With ordinary coatings, this means applying many coats. However, Unichrome Plastisol Compounds build up 3 mils to $\frac{3}{16}$ " thicknesses with a single prime and a single top coat. They "cure" to stable form at 350° in only 20 minutes.

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Bleach reduction chambers of a noted chemical producer were coated with a Unichrome Plastisol Compound. This user reported that the coating gave 4 times longer service than even special alloy metals before requiring maintenance!

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linings in equipment for spinning synthetic fibre with a Unichrome Plastisol Compound. By so doing, they ended build-up of hard sulfide deposits.

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When battling corrosive liquids and fumes, plastisol coatings are so thick and tough they can be depended on not to break or wear through. That's why they're used to coat drain boards, to line pipe and fittings, to protect ventilating fans, ducts, solution agitators, processing baskets and the like.

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Two Sessions—

(Continued From Page 28)

veloped into a form practical for mass industrial laboratory tests is described. The technique obviates removal of the corrosion products and permits detection of corrosion to a fraction of a microinch. It can be adapted to virtually any corrosive medium and condition.

Principal usefulness of the method is in establishing the relative corrosiveness of media which are closely alike. Several typical applications are: 1. Determination of relative corrosivity of crude oils at refinery temperatures. 2. Search for the corrosive agents in a refinery vis-breaking unit in an attempt to find the feed components responsible for accelerated corrosion in the evaporator tower. 3. Determination of the corrosivity of sulfuric acid sludges. 4. Quantitative method for evaluating effectiveness of oil-soluble rust inhibitors. 5. Determination of the corrosivity of oxidized lubricating oils to lead as a function of the oil oxidation time.

Abstract

Important Advantages of Titanium in the Chemical Industry. By W. G. Renshaw and P. R. Bish.

Valuable properties of titanium are discussed with emphasis on its good resistance to specific types of corrosion, including pitting, stress and intergranular corrosion. Titanium's influence in making design problems simpler is discussed.

Passivity of titanium under oxidizing conditions resembles that of certain other metals but is distinctly different under some conditions. Some conditions which promote passivity and a stable passive state are discussed. Inhibitors are unusually effective in certain corrosive media where other passive metals are not benefited. Studies of titanium's passivating characteristics and the presence or absence of certain components in the environment may explain behavior of the metal in dry halogens and certain other media. Moist environments appear to be conducive to passivity while the reverse is often true for other metals in some of these severe applications.

Abstract

Corrosion Resistance of Cupro Nickel Alloys Containing 10-30% Nickel. By F. L. LaQue.

New Horizons in Volatile Corrosion Inhibitors. By Bernard Fischlowitz.

The concept of corrosion prevention by means of a volatile chemical has led to a broadening knowledge of what volatile corrosion inhibitors will do, where and how they should be used and the savings in time, materials, labor and investment that can be effected by their use.

Vapor Phase Inhibitor and other commercially available volatile corrosion inhibitors are designed primarily to prevent rust of ferrous metal, but they have proved effective also when used to protect ferrous metals in assemblies incorporating non-ferrous metals. A few metals, notably cadmium and magnesium, are adversely affected by VPI.

Investigations are under way now into other volatile chemicals for use in packaging non-ferrous metals to prevent their corrosion.

Abstract

Effect of Design, Fabrication and In-

stallation on the Performance of Stainless Steel Equipment. By James A. Collins.

Case histories are presented of failures in austenitic type stainless steel chemical process equipment the recurrence of which have been prevented by improved design, better fabrication or installation. Thermal fatigue, concentration cell corrosion and stress corrosion cracking failures are considered.

Aluminum Heat Exchanger Tubes in the Process Industries. By W. W. Binger and H. W. Fritts.

About the Authors—

(Continued From Page 28)

of scientific groups in the United States and Canada. He has appeared as instructor at several short courses in which the National Association of Corrosion Engineers has participated, was principally responsible for organization of the Inter Society Corrosion Committee, is a past president of NACE and has otherwise busied himself with corrosion matters of all kinds. He is head of the Corrosion Engineering Section, Development and Research Dept. The International Nickel Co., Inc., New York, N. Y.

WILLIAM G. RENSHAW—Employed in the Corrosion Section, Allegheny Ludlum Steel Corporation's Research Laboratory since graduation from Penn State University in 1940 with a B.S. in chemical engineering.

S. W. SHEPARD—For seventeen years he has been occupied with materials engineering for American Cyanamid Company. This involved evaluation of materials of construction for fabrication of process equipment for almost all phases of his employer's manufacturing activities. Besides NACE he is a member of ASTM, ASM, The Electrochemical Society and the National Research Council.

BOOK REVIEWS

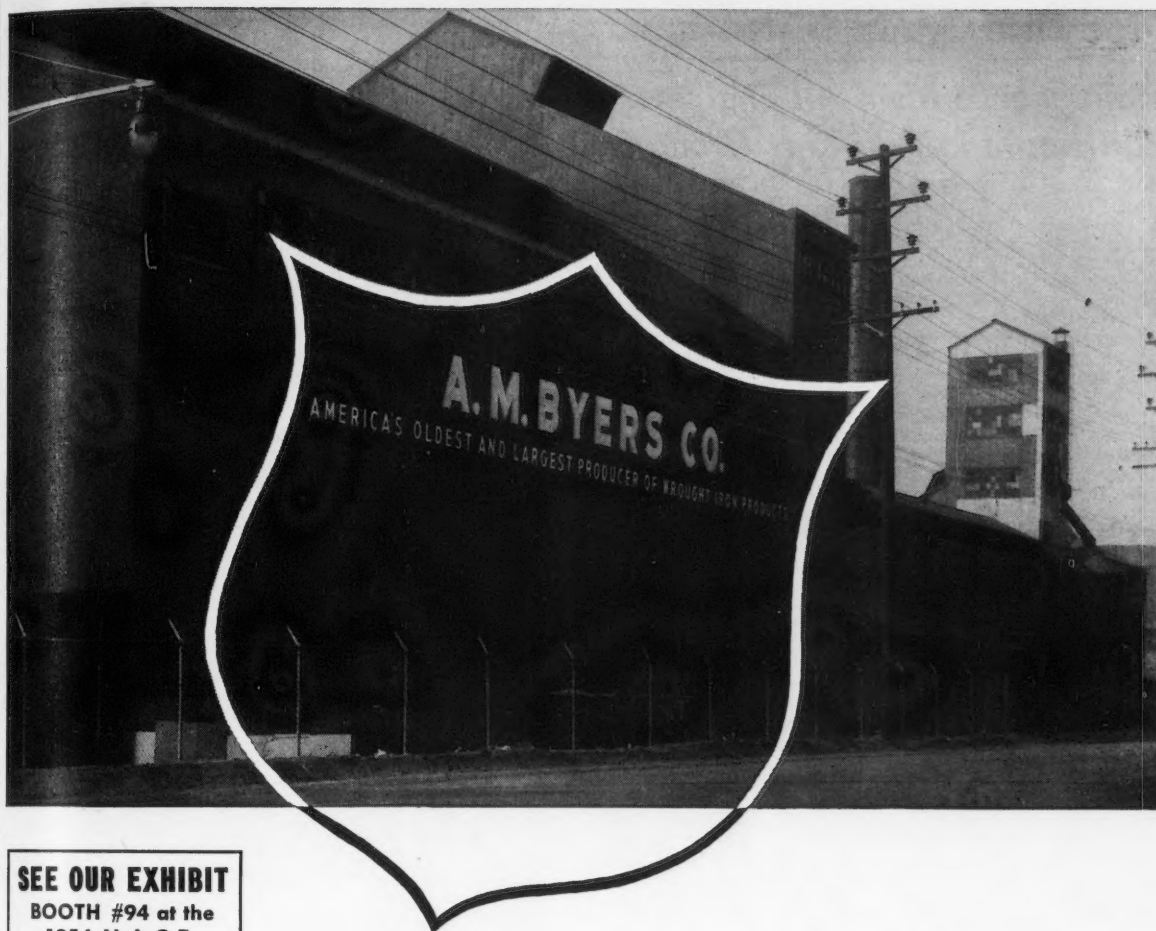
(Continued From Page 26)

Cathodic Protection of Pipelines and Reservoirs. By A. Pritula. (1950) In Russian. (Translation by E. Gros, 50 Alexandra Road, St. John's Wood, London N. W. 8 being published by Department of Scientific and Industrial Research, 10 shillings.)

In effect the book presents theory and application of electrical protection of pipelines as practiced in Russia. No significant new discoveries or theories are exposed, and while the appended references are all to Russian sources, the book's content follows substantially earlier publications on the subject in the United States.

Topics covered include cathodic protection fundamentals, measurements, design data on cathodic protection installations, anode systems, sources of current and operation and maintenance of cathodic protection installations. It appears that there is extensive use in Russia of windmills and also of primary batteries as sources of current for cathodic protection systems. The book contains 90 figures and 57 tables.

The author estimates Russian losses to underground corrosion to be 1,000,000 tons of metal per annum computed on a basis of 3 percent. The chapter on economics deals with depreciation values on various types of equipment.

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Pipe Line Group Discussions

Maintenance Men, All Engineers Invited to Participate in Pipe Line Group Discussions

An invitation to attend the Pipe Line Group Discussions to be held during the NACE Tenth Annual Conference and Exhibition at Kansas City, March 15-19 has been issued by Frank I. Dorr, Jr., Trunkline Gas Co., Houston and R. L. Bullock, Interstate Oil Pipe Line Co., Shreveport, who are in charge of the program. The eight discussion groups, each to consist of not more than 40 persons, are open to members and non-members of NACE alike.

Success of the discussion groups at the 1953 NACE Conference in Chicago resulted in their being offered again during the Kansas City meeting. Because there is no limit to the number or type of questions asked the sessions are useful alike to experienced engineers and those only recently assigned to corrosion control duties. An experienced corrosion engineer will act as moderator of each group and, in addition, an added panel of some of the nation's best known experts on underground corrosion will be available for consultation when necessary.

Organizers of the discussions point out they are especially useful to maintenance superintendents and others who do not devote their full time to corrosion control. Mutual discussion of corrosion problems has been found the most effective way to disseminate corrosion-mitigation discoveries among men concerned with pipelines.

Advisors:

O. C. Mudd, Shell Pipe Line Corporation, Houston, Texas.
S. P. Ewing, The Carter Oil Company, Tulsa, Oklahoma.
M. E. Parker, Cormit Engineering Company, Houston, Texas.
R. A. Brannon, Humble Pipe Line Company, Houston, Texas.
H. W. Wahlquist, Ebasco Services, Inc., New York, New York.
N. P. Peifer, The Manufacturers Light & Heat Company, Pittsburgh, Pennsylvania.
J. P. Oliver, National Carbon Company, Cleveland, Ohio.

Discussion Group Leaders are:

L. R. Sheppard, Shell Pipe Line Corporation, Houston, Texas.
F. R. Blankenship, Southern Natural Gas Company, Birmingham, Alabama.
D. C. Glass, Pure Transportation Company, Chicago, Illinois.
W. J. Kretschmer, Columbia Gas System Service Corporation, Columbus, Ohio.
M. C. Callahan, Gulf Refining Company, Tulsa, Oklahoma.
L. G. Sharpe, Humble Pipe Line Company, Houston, Texas.
L. F. Heverly, Great Lakes Pipe Line Company, Kansas City, Mo.
J. O. Mandley, Michigan Consolidated Gas Company, Detroit, Mich.
W. E. Broyles, Brance-Krachy Company, Inc., Houston, Texas.
R. L. Featherly, The Dow Chemical Company, Midland, Michigan.
M. A. Riordan, Rio Engineering Company, Houston, Texas.

R. J. Emerson, El Paso Natural Gas Company, El Paso, Texas.

A. W. Peabody, Ebasco Services, Inc., New York, New York.

E. P. Doremus, Cathodic Protection Service, Houston, Texas.

G. L. Doremus, Cathodic Protection Service, Houston, Texas.

J. C. Berringer, Panhandle Eastern Pipe Line Company, Kansas City, Mo.

W. Graber, Panhandle Eastern Pipe Line Company, Liberal, Kansas.

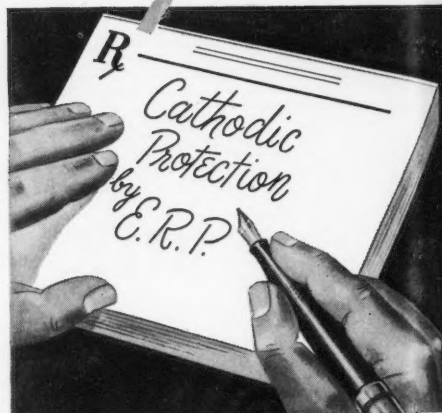
Inspection of Papers Available Is Planned

Although NACE does not provide pre-print copies of technical papers presented at its meetings, an opportunity will be given representatives of the press to examine copies of papers available at the time of the conference. The association's policy is that up to one-third of a technical paper may be extracted for review.

Papers themselves are not available for publication until after they have been reviewed and published in the association's official journal CORROSION. Reprinting privileges are freely given provided reference to the original publication is made.

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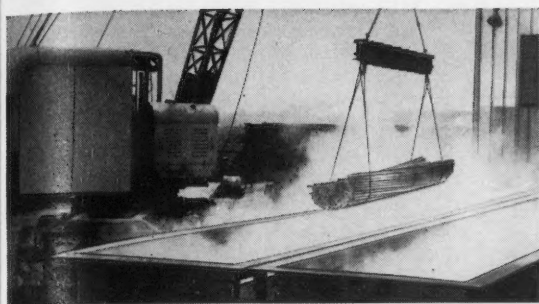
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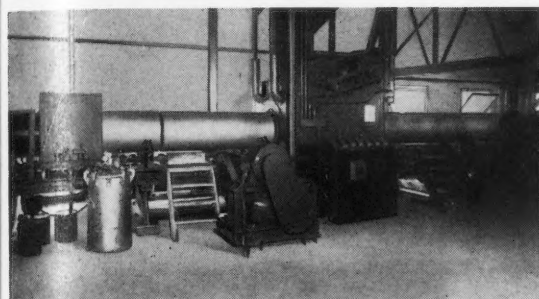
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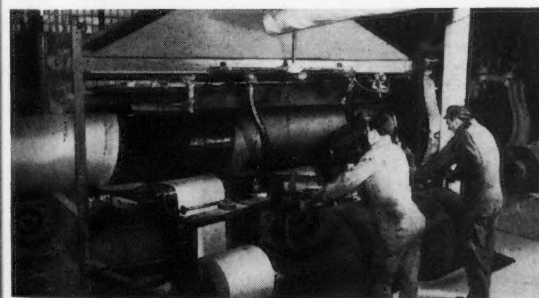
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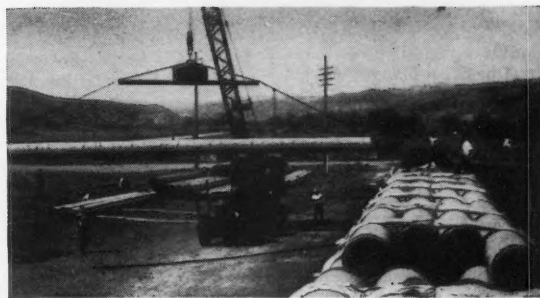
HOT CAUSTIC DIP removes all cutting oil and grease. Pipe is then rinsed in clear, hot water and dried in warming room. Throughout Hill, Hubbell process, pipe is kept at 80-90° to prevent moisture condensation.



ROTO GRIT BLAST removes all mill scale and rust, cleans pipe to bare, bright metal, provides a slight "tooth" to hold coatings in positive bond. Priming coat is applied immediately after Roto Grit Blast.

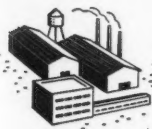


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ELECTRONIC holiday detectors inspect every length of pipe before it leaves a Hill, Hubbell plant—further insurance that coatings have dielectric strength to resist electrochemical corrosion underground.

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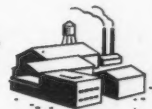


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Avila



Gibson



Jones



Plym

About the Authors

C. F. AVILA—Section Head, Service Section, Engineering and Construction Department, Boston Edison Co. Mr. Avila, who received a BS in Engineering and Business Administration from Harvard University in 1929 after a 5-year course which combined electrical engineering and business administration, has been actively connected with various phases of physical design and operation of outside plant of Boston Edison Company since he joined it in 1929. In 1942 he was named head of the company's Technical Division of the Transmission and Distribution Department and has been in his present position since 1952 with responsibility for surveying records, transmission rights of way and estimating in addition to plant design. He has specialized in cable engineering and electrolysis mitigation and has written a number of papers describing developments new at the time.

SIDNEY A. GIBSON—Corrosion Engineer for Tennessee Coal & Iron Division of United States Steel Corp. is in charge of all corrosion mitigation measures in all the mining, manufacturing and transportation facilities of his company. He holds a BS degree in electrical engineering from Alabama Polytechnic Institute and was first employed by Tennessee Coal & Iron Division as a research and testing engineer. He took his present position in 1951.

A. B. JONES—Mr. Jones for 25 years has been associated with the Boston Edison Company dealing with technical problems connected with construction, operation and maintenance of outside electrical transmission and distribution plant. Prior to this he was for five years with Arkansas Power and Light Co. as distribution engineer, making layouts, estimates and supervising construction of overhead and underground distribution and street railway systems. He is a graduate of Colorado School of Mines with an EM degree, 1921.

L. M. PLYM—He has been Electrical Coordination Engineer of the Illinois Bell Telephone Company, Chicago Area, for many years. In an advisory capacity he has been interested in lead cable sheath corrosion and has participated in the design of several cathodic protection systems. He holds bachelor and professional degrees in electrical engineering and is a member of NACE and the Western Society of Engineers.

J. P. PRIME, JR.—Protection Engineer for Florida Power & Light Company. He handles all corrosion mitigation work on the company's system. He holds a BS in electrical engineering from University of Miami. A World War II army air corps veteran, he is a member of AIEE and NACE.



Prime



Roselle

D. T. ROSSELLE—He is Cable Maintenance Results Supervisor assigned to the General Plant Manager's Staff of Southern Bell Telephone and Telegraph Co., Atlanta, Ga. He has had 22 years' experience with the telephone company in plant and engineering work and has been actively associated with corrosion mitigation for 13 years. He is a member of AIEE and NACE.

Extensive Experience Of Authors Adds to Interest in Papers

Authors of long experience with corrosion problems in the power and communication industries are presenting papers at the symposium devoted to these industries at Kansas City. The five papers scheduled cover as many topics interesting to either the communications or the power plant engineer or to both.

R. M. Lawall, American Telephone and Telegraph Company, Cleveland, is chairman and **L. O. McCormick**, Consolidated Gas Electric Light and Power Company, Baltimore, co-chairman of the symposium.

The five papers scheduled are:

Abstract

Cooperative Test Methods for Corrosion Mitigation Problems in Urban Areas.

By **D. T. Roselle**.
Corrosion of subsurface metallic structures can be expected unless mitigative measures are adopted. Cathodic protection is extremely difficult to apply to a single plant without subjecting adjacent plants to a hazard, so cooperative handling of the problem is the only logical solution. If it is necessary to protect one plant independently of others the hazard to adjacent plant can be minimized or eliminated by distributed anodes, dis-

tributed cathodes or by cross-bonding to reduce current exchange through the soil or stop current pickup at its source.

Abstract

Some Experiences With Cathodic Protection in Chicago. By **L. M. Plym**.
Removal of street car rails in parts of Chicago has necessitated the use of cathodic protection for many sections of lead sheathed telephone cables. For each of several situations data have been collected as follows: 1. Type of power supply. 2. Design of ground bed. 3. Current and voltage requirements. 4. Cable sheath potentials. 5. Amount of cable protected and 6. First cost and power cost.

Abstract

Positive Polarity Grounding of DC Supply Equipment in Mining Traction Systems.

By **Sidney A. Gibson**.
Difficulties resulting from positive polarity grounding of DC Supply equipment in the mining industry have reached serious proportions. Experience of the mining division of Tennessee Coal & Iron Division, U. S. Steel Corp. indicates the practice causes corrosion of underground structure, abnormally increases maintenance costs due to excessive failures of trolley insulators and affects mine safety because of the possibility pure metallic sodium or potassium may be formed.

Two most recent mining developments of the Division used positive polarity grounding or negative trolley traction system. Satisfactory operation followed for three years, and then excessive failures of trolley insulator hanger assemblies and supports began as a result of deterioration or corrosion of the assemblies and the adjacent roof rock. Chemical analyses of corrosion formations and roof strata were made, stray current and voltage tests, drip tests on damaged insulators and other tests were carried out. These indicated three factors existed: 1. A source of salts and acids. 2. Sufficient moisture to form an electrolyte and 3. A flow of current in a direction such that metals were withdrawn from roof strata. Pure metals, if formed thus, constitute a safety hazard because they can cause serious skin burns and will react violently in contact with water.

Detailed discussions and recommendations for corrective methods are included.

Cathodic Protection on Power Plant Intake Screens.

By **J. B. Prime, Jr.**
The history of protecting cathodically intake screens, i.e. trash gates, rotating screens and fine or fixed screens at various plants of the Florida Power and Light Company is reviewed. The paper covers the development of cathodic protection systems at the plants from the beginning to the present. Drawings of anode trays show their position in the intake well with respect to the screens and circuit drawings show the test panel where current is controlled between rectifiers, anode clusters and screens. Tests and their associated results are discussed pertaining to current distribution, materials and construction techniques.

Abstract

Special Corrosion Problems of Electric Utility Systems.

By **C. F. Avila** and **A. B. Jones**.
A large number of corrosion problems on outside plant of electric power com-

(Continued on Page 36)

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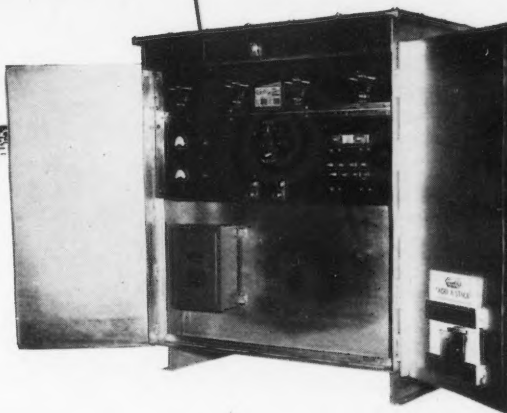
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About the Authors

JOHN C. HOWELL—Since 1937 he has been electrolysis engineer for Public Service Electric and Gas Company of New Jersey. He holds a Pratt Institute degree in electrical engineering (1925) after obtaining which he was a student engineer with General Electric Company in the Schenectady testing department. He was employed by Public Service Electric and Gas Company in 1928 in its high voltage laboratory and upon completion of this assignment in 1932 was active in organizing a corrosion department. He is co-chairman of NACE Technical Practices Sub-Committees 16B and 16D.

FRANK E. KULMAN—Engineer with Consolidated Edison Company of New York, Inc., has been employed by that concern in testing and design work for 26 years. Most of this time has been devoted to investigating and solving electrolysis and corrosion problems on New York City underground cable and gas pipe. Active in committee work with AIEE, AGA and NACE, Mr. Kulman holds a BS degree from College of the City of New York and EE and MEE degrees from Polytechnic Institute of Brooklyn. He is a member of NSPE.

FRANCIS W. RINGER—A consulting engineer, Mr. Ringer lives at Narberth, Pa. He was for many years with Oklahoma Pipe Line Company, Tulsa, active in corrosion control work and afterwards worked for other pipe line and engineering firms. Mr. Ringer is one of the early members of NACE.

L. G. SHARPE—He is currently chairman of Houston Section NACE. An early member of NACE, Mr. Sharpe has been occupied with production and research in protective coatings, with the various aspects of protecting petroleum transportation equipment from corrosion. He is with Humble Pipe Line Co., Houston and is a graduate of Rice Institute, Houston. Mr. Sharpe also is chairman of Technical Practices Committee 18 on Internal Corrosion of Facilities for Storage and Transportation of Corrosion.

Extensive Experience—

(Continued From Page 34)

panies are considered, including some which are often neglected. Specific recommendations are made for solving a wide variety of corrosion problems involving corrosion cracking, galvanic action between steel and copper, aluminum and brass and cables with and without fireproofing.

Several unique corrosion problems are considered including water pockets, spot welded joints, concrete corrosion of lead and nitrous oxide attack where corona forms.

An original steel subway transformer design is described. Several hundred of the new design are giving superior performance.

Interference and Stray Current Problems Are Covered in Papers

Knotty problems that face engineers responsible for cathodic protection systems where interference with adjacent structures or where stray currents are significant are covered in three of the four papers scheduled for the Cathodic Protection Symposium to be given at Kansas City in March. The fourth paper is one on the extremely important subject of economics of pipe line corrosion mitigation.

The symposium, which has as its chairman O. W. Wade, Transcontinental Gas Pipe Line Corp., Houston, will include data on protective systems installed in congested areas.

The papers scheduled are:

Abstract

Fundamental Measurements for Corrosion Investigation. By J. C. Howell.

The electrochemical nature of corrosion provides a practical method of measuring the indicated effects by electrical values. The fundamental concept of current in corrosion is developed to show the difference between stray and local cell action and the characteristics of their measurement. Examples of stray current corrosion investigations are given along with computations involved in deciding on adequate drainage. Cathodic and anodic areas created by both stray and rectifier currents are described and methods of mitigation outlined.

A brief discussion of the types of instruments used in making corrosion investigations in the field and the reasons for their selection is given. A description of the stray current problems in New Jersey is included to illustrate involved conditions that can exist.

Tests and measurements relative to cable failures caused by local cell corrosion in both manholes and duct sections are covered and usual methods of mitigation briefly discussed.

Abstract

Solution of Cathodic Protection Interference Problems. By F. W. Ringer.

When cathodic protection is applied to an underground structure there is a possibility corrosion on nearby unprotected structures may be accelerated as the result of interference currents. This paper describes a method of obtaining data which permits determination of the extent of interference before permanent installations are made and indicates

whether or not a bond between structures to prevent interference is needed. The bond resistance can be calculated on an engineering basis.

Data obtained by the method are as accurate as can be obtained in minimum field time and thus eliminates cut and try methods and the need for extensive surveys before and after permanent installations are made.

The method was evolved about 20 years ago by the late Dr. J. M. Pearson of Sun Oil Co. in connection with his development of engineering methods for investigation and control of stray currents. Because cathodic protection currents are of the same nature as stray currents with the exception they are controllable and steady, Pearson's method has been found very useful in cathodic protection work. It is based on the fact the resistance through earth between structures and the resistance between structure and earth in a given location is constant and can be treated mathematically. On this basis underground structures are considered an electrical network, thus permitting solving cathodic protection problems by measuring network constants at the proper location. Mathematical treatment of the data thus obtained provides required solutions easily and quickly.

Proper location of a ground bed to minimize effect of interference on foreign structures is discussed. When ground beds are improperly located interference current may develop on the foreign structure which cannot be eliminated by a bond. There generally is always a correct location for a ground bed to reduce interference flow, and which is in the right direction to permit solution by bonding.

Economics of Pipe Line Corrosion Mitigation. By L. G. Sharpe.

Economics of controlling the internal corrosion of sour crude oil pipe lines and storage tanks is discussed. Protective measures considered are internal linings, corrosion inhibitors, non-metallic materials of construction and non-ferrous metals as materials of construction. Economics of coatings and cathodic protection for controlling external corrosion of pipe lines and tank bottoms is examined.

Abstract

Corrosion Control of Underground Power Cables in New York. By F. E. Kulman.

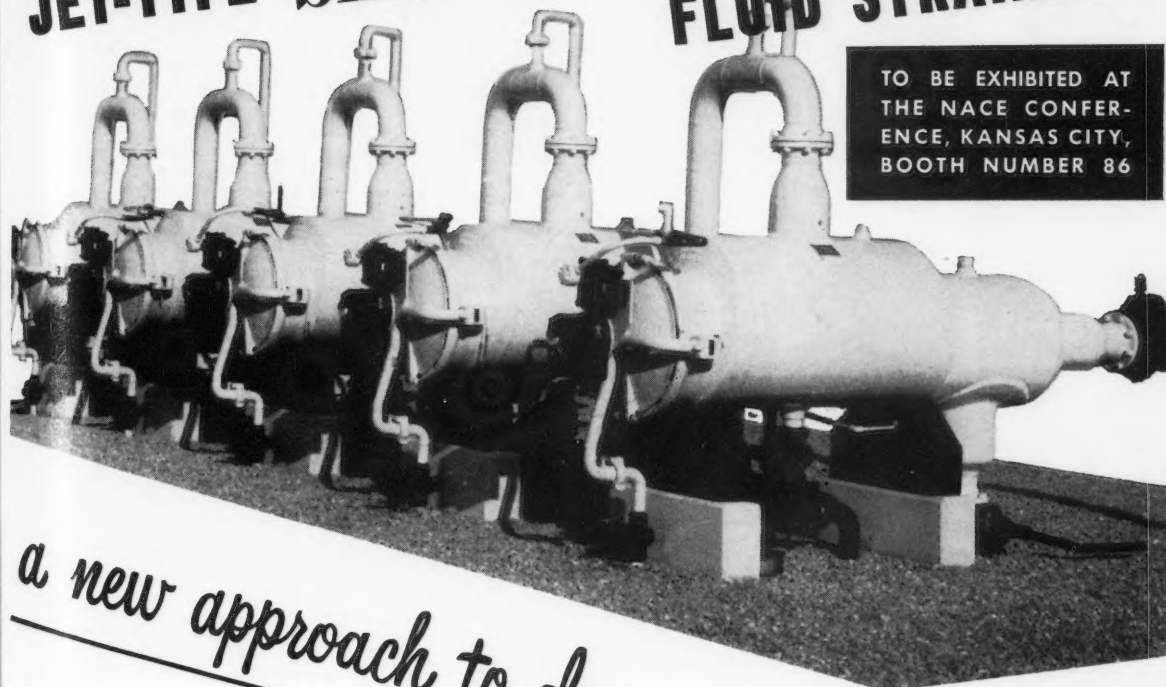
Effective control of cable sheath and pipe corrosion is obtained by a program of electrolysis surveys and tests and the design and installation of mitigative equipment and measures. Periodic testing is required.

Locations of corrosive areas are determined by exploring a vacant duct with a probe equivalent to a one-foot length of cable. Measurements are made of potential difference, and current and resistance. These indicate whether the cable is anode or cathode at the test point, and by magnitude of the emf if fluctuating, whether it is the result of stray or galvanic currents. Magnitude of the current flowing between operating cable and probe indicates rate of corrosion. Resistance measurements give clue to relative area of cable sheath in contact with electrolyte and hence an approximation of the sheath area from which current is discharged. Experience

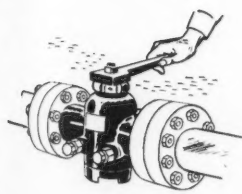
(Continued on Page 38)

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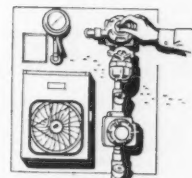
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About the Authors

FRANK CHUCK—He is engineering supervisor in charge of corrosion engineering, equipment inspection, welding inspection, quality control and testing and industrial engineering for Creole Petroleum Corp., La Salina, Venezuela. He has been with Creole since receiving his BS in mechanical engineering from Oklahoma University in 1947. He served as a naval officer in World War II and is a member of NACE and ASME.

FRANK E. DAVIE—Since 1951 he has been Area Corrosion Engineer, Pacific Coast Area, Shell Oil Company production department. A graduate of University of California in 1923 in chemistry, he first went to work for Shell in 1926.

PAUL DELAHAY—Associate professor of Chemistry at Louisiana State University, he holds MS and PhD degrees in chemistry and an MS in electrical engineering. He is author of more than 50 papers on kinetics and thermodynamics of electrode processes, electrochemical methods of analysis and metallic corrosion.

HASSAN S. GAMGOUM—A graduate assistant at Louisiana State University where he is working toward his PhD degree.

JOSE O. JULIANO—A graduate assistant at Louisiana State University and formerly an instructor at the University of the Philippines.

JACOB E. STRASSNER—Now working towards his PhD degree at Louisiana State University. He is author of several papers on the theory of polarography.

Indexes Delayed

Issuance of Author and Subject Indexes to the Battelle Technical Review has been postponed. All recipients of the "Review" will be notified when these indexes become available the Battelle Memorial Institute reports.

Well, Pipeline and Inhibitor Study Papers to Be Given

Papers on corrosion control of pumping wells, of pipeline systems, of the use of radiotracers to check inhibitor efficiency and on production equipment stress corrosion cracking are scheduled for the Oil and Gas Production Symposium at Kansas City. Reports on practical experience and laboratory tests are included.

R. C. Buchan, Humble Oil and Refining Co., Houston, and E. C. Greco, United Gas Corp., Shreveport, La. are chairman and co-chairman respectively. The papers are:

Abstract

Survey of Corrosion Control in California Pumping Wells. By Frank E. Davie and Preston W. Hill.

Results of corrosion control in a representative group of California wells are summarized. Data was furnished by NACE TP-1A on Corrosion of Oil and Gas Well Equipment, California and was collected and correlated using hand punch cards. Data covers 12 fields and 9 companies and some 350 wells varying from 1000 to 8000 feet in pump depth and producing up to 1000 barrels daily gross.

The survey indicates inhibitors have produced so far an average of 50 percent reduction in pulling jobs. Material replacements have been reduced by an even greater percentage.

Abstract

Application of Radiotracers to the Study of Inhibitors in Corrosion of Steel by Oil Well Fluids. By Paul Delahay, Hassan S. Gamgoum, Jose O. Juliano and Jacob E. Strassner.

Experimental methods are described for the study of the kinetics of the desorption of adsorption inhibitors from steel. Specimens coated with a monolayer of inhibitor are desorbed in a medium which initially does not contain any inhibitor. The inhibitor is labeled with Carbon 14 and surface concentration determined by means of an end-window counter. Desorption process is followed by repeating measurements at various time intervals.

In media containing sulfide ions desorption is complicated by progressive coating of specimen by ferrous sulfide.

Rate of the latter process is followed by adding to the corroding medium a small amount of tagged sulfide (Sulfur 35). Results are summarized in diagrams showing variations of the following quantities with time: Surface concentration of inhibitor and the rate of corrosion. Conclusions are drawn as to the degree of protection achieved by systems in which an adsorption inhibitor is injected periodically.

Abstract

Corrosion Control of Creole's Lake Maracaibo Pipeline System. By Frank Chuck.

More than 1200 miles of pipeline are needed to handle Creole Petroleum Corporation's Lake Maracaibo production of up to 700,000 barrels of oil daily and move it from wells to flow stations and then to terminals on shore.

The corrosion history of the lake pipelines is given, including coating practices of the 1930's, the switch to bare pipe during World War II and the resumption of pipe coating in 1951. Life histories of all pipelines are kept by Creole's corrosion engineering section and from these much useful information can be drawn. Statistical studies on the corrosion rates of bare pipelines and the annual cost of corrosion are presented. Effectiveness of magnesium anodes and rectifier protection on bare pipelines is discussed.

Abstract

Sulfide Corrosion Cracking of Production Equipment. By R. S. Treseder.

Field experience with sulfide corrosion cracking of production equipment, particularly tubing and casing in sour and gas-condensate and high pressure sour oil wells is summarized along with data from recent field tests. Preventive measures are described including selection of materials with minimum susceptibility to cracking and inhibitors. Laboratory and field test methods are reviewed.

General status of the sulfide corrosion cracking problem as it exists is described and future problems involved in very deep sour wells considered.

Interference and—

(Continued From Page 36)

makes possible, by using these data, estimating the expected life of the cable.

At 110 locations a total of 5500 amperes of stray current is drained from cables to rapid transit grounds. Cathodic protection is applied to mitigate corrosion caused by soil conditions.

Pipe type cable systems are coated with asphalt mastic and a 2-volt storage battery connected in series with the ground connection at each end of the pipe.

Existing test methods are satisfactory for stray current and galvanic current surveys but they are inadequate in estimating severity of corrosion caused by soil. Lack of aeration being one of the primary factors in soil corrosion, it is necessary that more attention be given to quantitative determination of soil aeration or the reduction-oxidation potential of the soil. The Starkey and Wight soil redox probe appears to be suitable for measurements in wet soils but requires further development for dry or moist soils.

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Pipe Line and Underground Corrosion

General Corrosion Problems Round Tables

Round Table Discussion Sessions Always Are Popular at Annual NACE Conferences

The Pipe Line and Underground Corrosion Round Table and the General Corrosion Problems Round Table have proved to be among the most popular events on the technical program at NACE Conferences. These discussion sessions, featured by the free exchange of information, are unrehearsed, unrecorded and informal.

Y. W. Titterton, Pipe Line Anode Corp., Tulsa, is chairman and J. P. Barrett, Stanolind Oil and Gas Co., Tulsa, is co-chairman of the Pipe Line session.

L. E. Stout, Washington University, St. Louis, is chairman and A. O. Fisher, Monsanto Chemical Co., Everett, Mass., co-chairman of the General Problems session.

Room Assignments For Principal Sessions

Assignments of room to the principal events scheduled during the NACE Tenth Annual Conference and Exhibition at Kansas City in March have been made as follows:

Monday, March 15

T. P. Committee Meetings, see detailed list elsewhere.

Tuesday, March 16

Morning

9-10—General Business Meeting—Little Theater, 1st Floor.

10-11:30—Corrosion Principles Symposium—Little Theater, 1st Floor.

10-11:30—Non-Destructive Testing Symposium—Room 600, 6th Floor.

Afternoon

2-4:30—Refinery Industry Symposium—Little Theater, 1st Floor.

2-4:30—Costs of Corrosion Symposium—Room 600, 6th Floor.

4:30-5:30—Educational Lecture: Corrosion Fundamentals No. 1—Little Theater, 1st Floor.

Movies

2:30-3:30—Room 400, 4th Floor.

Wednesday, March 17

Morning

9-11:30—Chemical Industry Symposium—Little Theater, 1st Floor.

9-11:30—Pipe Line Coatings Symposium—Room 600, 6th Floor.

Afternoon

2-4:30—Chemical Industry Symposium—Little Theater, 1st Floor.

2-4:30—Power and Communication Industry Symposium—Room 600, 6th Floor.

2-4:30—Pipe Line Group Discussions—Hotel President; Rooms 211, 215, 217, 219, 221, 225, 227 and 229.

4:30-5:30—Educational Lecture: Corrosion Fundamentals No. 2—Little Theater, 1st Floor.

Thursday, March 18

Morning

9-11:30—Cathodic Protection Symposium—Room 600, 6th Floor.

9-11:30—Oil and Gas Production Symposium—Little Theater, 1st Floor.

Afternoon

2-4:30—Elevated Temperature Corrosion Symposium—Room 600, 6th Floor.

2-4:30—Pipe Line and Underground Corrosion Round Table—Little Theater, 1st Floor.

4:30-5:30—Educational Lecture: Corrosion Fundamentals No. 3—Little Theater, 1st Floor.

Friday, March 19

Morning

9-11:30—General Corrosion Problems Round Table—Room 600, 6th Floor.

9-11:30—Protective Coatings Symposium—Little Theater, 1st Floor.

Movies

2:30-3:30—Room 400, 4th Floor.

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Elevated Temperature Corrosion Symposium



Brush



Greene



Lad



Manly

About the Authors

R. S. TRESEDER—Mr. Treseder's biography is included under the heading Refinery Industry Symposium appearing previously in this section.

E. G. BRUSH—Since 1951 he has worked in the Metallurgical Engineering Unit of the Knolls Atomic Power Laboratory, principally investigating the behavior of engineering alloys in high temperature liquid metals. He holds a BS from Massachusetts Institute of Technology and before joining Knolls worked for five years as corrosion engineer in the General Electric Company's Chemical Division.

RICHARD J. GREENE—Now a member of the International Nickel Company's Field Service personnel, he was graduated from Rensselaer Polytechnic Institute in 1942 with a BS in metallurgical engineering. He was employed as production control metallurgist at Wyman-Gordon Co. on graduation working with steel, aluminum and magnesium wrought alloys. In 1945 he became associated with Inco, joining the staff of the Research Laboratory and specializing on the development of cast ferrous materials.

ROBERT A. LAD—Head of the Chemistry of Materials Section, NACA, Lewis Flight Propulsion Laboratory. He has an MS in physical chemistry and a PhD in inorganic chemistry from University of Chicago. His experience includes research in boron hydride chemistry, gas adsorption, mass spectrometry and hydrocarbon combustion. For four years he has been working in solid state physics and on the mechanism of mass transfer and corrosion in molten salts and hydroxides.

WILLIAM D. MANLY—Presently with the Oak Ridge National Laboratory, he has conducted research on materials problems in nuclear reactors. Educated at Antioch College and at the University of Notre Dame, he worked at Battelle Memorial Institute while attending Antioch and as a research fellow at Notre Dame. After receiving an MS from Notre Dame he began working at the Oak Ridge laboratory. He is a member of the ASM, AIME and NACE.

FREDERICK G. SEFING—He came to work for The International Nickel Co., Inc., in 1937 after teaching metallurgy for 15 years and doing consulting work for 10. He is concerned with the development of alloyed cast irons, including problems of production and special casting uses involving resistance to heat, corrosion and wear. He was graduated from Lehigh University in metallurgical engineering and has an MS from Penn State University.

Additional copies of CORROSION are available at 50c each to NACE members and \$1 each to non-members.



Sefing

High Temperature Corrosion Data on Metals to Be Given

Data on the relative corrosion resistance of several metals subjected to high temperatures will be given in the five papers to be presented during the Elevated Temperature Corrosion Symposium. These include information on cast irons, ductile cast irons used for grate bars and the corrosion behavior of high alloys subjected to molten salts. These latter materials and conditions are those common in atomic fission installations.

G. A. Fritzlen, The Haynes Stellite Company, Union Carbide and Carbon Corp., Kokomo, Ind., is chairman, and E. N. Skinner, The International Nickel Co., Inc., New York, co-chairman of the symposium.

The papers to be given are:

Abstract

Cast Irons in High Temperature Service. By Richard J. Greene and Frederick G. Sefing.

Cast irons in grate bars and furnace doors until recently have been compared principally on their comparative growth properties. Since this did not evaluate the life expectancy accurately, tests on the rate of oxidation or oxygen penetration rates in inches penetration per year were conducted. These tests are described in this paper, with results on plain and low alloyed cast irons and highly alloyed austenitic cast irons in several environments. Some description of how cast iron deteriorates with growth also is included. Various typical applications of simple cast irons, low alloyed cast irons, austenitic cast irons and the ductile varieties of cast iron and austenitic cast irons are described with the engineering reasons for their economical use in high temperature service.

Abstract

Oxidation of Plain, Alloyed, and Ductile Irons at 1300°F. By J. A. Cameron.

Oxidation tests of up to 4000 hours duration at 1300 degrees F were made on ordinary flake graphite gray irons, ductile iron and on highly alloyed cast iron having both flake and spheroidal graphite. It is concluded that ductile irons possess resistance to oxidation markedly better than that of flake graphite irons. In highly alloyed irons the difference is less pronounced at this temperature. Specimens were exposed in an atmospheric tempering furnace equipped with fan for circulation of air.

Abstract

Corrosion Behavior of High Temperature Structural Metals in Fused Salts. By W. D. Manly.

Corrosion behavior of various structural metals has been determined in the fused fluorides and hydroxides in a temperature range of 600 to 800 degrees C. Results of these tests show nickel-base alloys have suitable corrosion resistance to fused fluorides for use in high temperature plumbing systems. Study shows the basic corrosion mechanism of fused fluorides on Inconel is the selective solution of chromium from the solid solution Inconel lattice. It has been found that additives will decrease the corrosive effect of the fluorides.

Only the more noble metals such as nickel, silver, gold, or copper have corrosion resistance at 800 degrees C in the hydroxide. However, these metals suffer from a phenomenon known as mass transfer which is characterized by the removal of metal from the hot portion and its deposition in the cold portion of a corrosion test employing a temperature gradient.

Abstract

Construction Materials for Liquid Sodium Systems. By E. G. Brush.

The use of sodium as a heat transfer agent in nuclear power plants has resulted in a new phase of corrosion technology to evaluate the surface properties of materials of construction for high temperature, irradiated, liquid metal cooled heat transfer systems.

In pure sodium, engineering alloys may be subject to mass transport effects, preferential solution of alloying constituents and diffusion welding of mating surfaces. Trace amounts of impurities, difficult to remove, result in damaging oxidation and also act to accentuate preferential solution phenomena, particularly decarburization and intergranular attack.

The resistance of alloys to attack by sodium has been investigated in static and in dynamic laboratory tests and in pilot plant heat transfer systems. Extensive laboratory data and service performance indicate that the design engineer has a wide selection of materials of construction that will give satisfactory service in high temperature sodium systems.

Abstract

A Study of Corrosion and Mass Transfer of Nickel by Molten Sodium Hydroxide. By Robert A. Lad and Sidney L. Simon.

Usefulness of nickel as a container material for molten sodium hydroxide is hampered at high temperatures by cor-

(Continued on Page 44)

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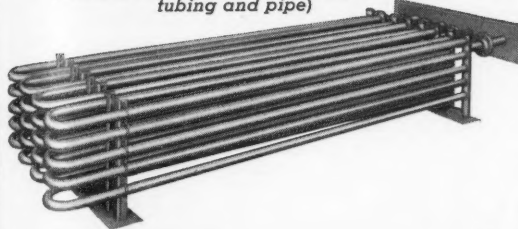
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Protective Coatings Symposium



Ingham



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About the Authors

HERBERT S. INGHAM—He is a vice-president and chief engineer of Metallizing Engineering Co., Inc., Long Island City, N. Y. Mr. Ingham has been in charge of design, development and manufacturing departments of his firm since 1937. He holds a BS in mechanical engineering from California Institute of Technology (1931) and has worked for Sterling Electric Motors and the Harder and Ingham Machine Company.

R. B. SEYMOUR—Mr. Seymour, who is technical director of Atlas Mineral Products Co., Mertztown, Pa., is a frequent contributor of technical material on plastics to *Corrosion*, and has appeared on the technical programs of many national, regional and section meetings of the NACE. He is author of a 500-page book now in press, "Plastic Materials of Construction" and of numerous other contributions to standard texts on plastics besides being the originator of 40 patents. A member of more than 20 American and foreign technical organizations, he is active as head of their committees and in other ways.

J. ROBERT SPRaul—Mr. Spraul is manager of the Research and Testing Laboratory of the General American Transportation Company, East Chicago, Ind. With a PhD in physical chemistry from Indiana University, Mr. Spraul has been research chemist for American Can Company, Maywood, Ill.; associate physical chemist and supervisor of physical chemistry research, Armour Research Foundation, Chicago and assistant to the director of the laboratory in which he is now manager.

Synthetic Resins, Tank Car Linings, Metallizing Covered

Some of the characteristics and uses of synthetic resins used for coatings, special tests for evaluating linings for tank cars and advantages of coating systems using sprayed metal underfilms are covered in the four papers of the Protective Coatings Symposium. Laboratory and in-service test data are included on some aspects of these materials.

N. K. Senatoroff, Southern Counties Gas Company of California, Los Angeles, is chairman and W. B. Meyer, St. Louis Metallizing Co., St. Louis, Mo., is co-chairman of the symposium.

The papers are:

Abstract

Laboratory and Plant Evaluation of Liquid Neoprene Coatings. By R. B. Seymour.

While natural rubber and some of the butadiene rubbers can be dissolved in organic solvents, none will yield a high solids solution similar to that obtained from Neoprene KNR. Neoprene was introduced about 20 years ago as a result of fundamental work by Father Nieuwland of Notre Dame University and subsequent investigation by Du Pont chemists.

Specialty grades of Neoprene for use in solutions—Neoprene AC, for adhesives and KNR for coatings are available commercially. While KNR may be softened on a mill more readily and is more soluble than other forms it resembles other vulcanized Neoprene products when cured. In its liquid form, Neoprene KNR is actually reinforced with carbon. The heavy film deposited has a greater resistance to abrasion and weathering than that of any other elastomer and in addition its resistance to impact, heat and corrosives is at least equal to those of the best thermoplastic protective coverings.

Thus liquid Neoprene, as a brushable or sprayable coating and trowel cement has been used for about 10 years to protect chemical process equipment. It is continually being rediscovered in testing programs, but, in spite of superior performance, Neoprene coatings are produced by less than 10 manufacturers.

Laboratory tests on films and coated panels show Neoprene to be essentially unaffected over long periods of time by inorganic alkalis, salts and most mineral acids. These tests have been substantiated under service conditions in ships, power plant equipment and in chemical process industries throughout the world.

Abstract

Coating Testing for Tank Car Linings. By J. Robert Spraul.

Corrosion problems associated with tank car shipments differ from those in stationary vessels because of frequent loading and unloading, and of incomplete unloading, the latter producing conditions in the tank conducive to serious damage.

Condition for preferred use and life requirement of interior coatings for tank cars are discussed. Corrosion factors such as dilution, aeration, liquid and vapor phase contact, presence of moisture, separation phases and heat are covered.

While long term tests would provide

best information on coating life, usually time requirements force reliance on accelerated studies. Testing methods are reviewed and their usefulness evaluated. In particular a testing method incorporating partial immersion of a coated panel, aeration, humidity and heat is described and results given.

Some data on actual tank car applications are presented.

Abstract

Metallized System Coatings. By H. S. Ingham.

Metallized coatings of zinc and aluminum have been used as protective coatings for iron and steel for about 40 years. Many coatings were used on bare metal without after painting, while many were followed by application of some kind of coating. There was formerly no organized way for using coatings over metallizing, the usual reasons for doing so being based on considerations of appearance and the coatings' suitability for steel, rather than its applicability to zinc or aluminum.

Experience proved, however, some types of paints increased the life of sprayed coatings while other paints were detrimental to them. About 10 years ago a development program was begun to evaluate organic coatings compatible with sprayed zinc or aluminum. This investigation showed some organic coatings produced results superior to those secured from either coating alone and this resulted in the investigation of coating systems combining metallic and organic materials.

Resulting were a number of commercial coating systems combining metallic zinc or aluminum with organic coatings, especially vinyls and rubbers. The new systems are thinner, less expensive and far superior to either plain metal coatings or plain organic coatings for the protection of iron and steel.

High Temperature—

(Continued From Page 42)

rosion and mass transfer whenever a temperature gradient is present in the system. Free convection studies at other laboratories and preliminary studies at NACA Lewis laboratory showed the amount of mass transfer is strongly affected by variables such as temperature level, temperature gradient, flow conditions, atmosphere and the chemical composition of both the caustic and the nickel. It was found that normal care in the control of these variables resulted in a reproducibility on the order of 200 to 300 percent. A free convection test was developed which yielded results reliable to plus or minus 10 percent and made it possible to study effects of the different variables and to investigate effectiveness of additives. Relation between mass transfer rate and temperature gradient was established in the temperature range 1400 to 1600 degrees F. Effects of additions of a large variety of materials to the caustic were studied also.

Induced flow experiments at velocities up to 15 feet per second were performed in an apparatus which permits independent variations of flow rate and temperature gradient. This system contained no other metal but that under study and required no pump, valves or flowmeter. A variety of additions were made to the caustic to provide data for comparison with those derived from free convection tests.

Popular Educational Lectures Scheduled For Presentation at Kansas City Conference

Three educational lectures are scheduled to be given during the Kansas City Conference in March. These popular items on the technical program were added because their first appearance at an NACE Conference in 1953 brought standing room only audiences. Those scheduled to be given this year are expected to be equally popular. Authors of long time practical and theoretical experience are scheduled to discuss fundamentals of stress corrosion, cathodic protection and the design and interpretation of field and service corrosion tests. The papers are:

Abstract

Educational Lecture on "Stress Corrosion." By J. J. Harwood, office of Naval Research, Washington, D. C.

The influence of stress and deformation on the nature, rate and distribution of corrosion reactions is discussed. Factors involved in stress corrosion attack are described, including composition, stress, environment, microstructure and time. A generalized mechanism of stress corrosion is presented and an explanation of stress corrosion cracking of several metals and alloys in terms of the mechanism made. The importance of surface films—their formation and breakdown—in stress corrosion reactions is emphasized. Methods of prevention are reviewed briefly.

Abstract

Cathodic Protection. By R. C. Weast, Case Institute of Technology, Cleveland, Ohio.

Cathodic protection will be discussed from the standpoint that it is basically the controlled application of electrical energy in opposition to the electrical energy released during normal corrosion of metal and that it involves an electrode, an electrolyte and the flow of an electrical current together with accompanying chemical reactions. Fundamental and simple applications will be outlined illustrating the role of resistance magnitude of current flow, polarization and the change in the potential of the protected metal.

Abstract

Design and Interpretation of Field and Service Corrosion Tests. By F. L. LaQue, The International Nickel Co., Inc., New York.

The paper reviews critically several methods of undertaking field and service corrosion tests and the interpretation and application of results. Attention is given to such details as selection of test materials, marking for identification, number of specimens to be tested, heat treatment and welding, effects of stress, surface finish, dimensions and shapes of test pieces, methods of support, possible galvanic effects, hot and cold wall effects, influence of corrosion products, examination of specimens after exposure, assess-

ment of damage and evaluation of results. Consideration of tests in natural environments and process solutions is included.

Registration Hours And Places Listed

Registration hours and places have been set as follows for the Kansas City Conference:

Sun., Mar. 14—12 noon-5 pm, 14th Street entrance only.

Mon., Mar. 15—7:30 am-5 pm, 13th and 14th Street entrances.

Tues., Mar. 16—8 am-5 pm, 14th Street entrance.

7:30 am-10 am and 1 pm-2:30 pm, 13th Street entrance.

Wed., Mar. 17—8 am-5 pm, 14th Street entrance.

Thurs., Mar. 18—8 am-5 pm, 14th Street entrance.

Fri., Mar. 19—8 am-9:30 am, 14th Street entrance.

All registration will be at the Municipal Auditorium. Exhibitor registrations are to be accepted at Registration Desk, 14th Street entrance only.

NYU Research Grows

Research activity of New York University's College of Engineering increased 14 percent during the last year and passed the \$2,000,000 mark. "Achievements of the research engineer are necessary to social and cultural progress, despite the fact that he is primarily preoccupied with the material world," Dr. Harold K. Work, director of the division said.

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Kansas City Exhibition to be NACE's Largest

What is already the largest exhibition to be held at a national conference of the National Association of Corrosion Engineers is likely to be even larger. O. E. Murrey, 1954 conference exhibition committee chairman, reported January 12 that 130 spaces had been sold to 90 companies in the Kansas City Municipal Auditorium for the March 15-19 meeting. This leaves only 11 of the 141 exhibit spaces remaining unassigned. Mr. Murrey believes more will be sold before the opening day of the conference and there is some reason to believe the exhibit will be sold out by that time.

The exhibit will be open to registrants at the conference and to visitors from 8 am to 5 pm on Tuesday, Wednesday and Thursday, March 16, 17 and 18, and from 8 am to noon on Friday, March 19. The variety and completeness of this year's exhibition make it well worth the special attention of those attending the conference, Mr. Murrey believes.


Following is a list of companies assigned space in the exhibition:

Alrose Chemical Co.
Aluminum Company of America
Amercoat Corp.
Ampco Metal, Inc.
Anderson-Prichard Oil Corp.
Apex Smelting Co.
Armour Chemical Division,
Armour and Co.
The Barrett Division,
Allied Chemical & Dye Corp.
Barrows Porcelain Enamel Co.
Bart Manufacturing Corp.
A. M. Byers Co.

Brance-Kracy Co., Inc.
Branson Instruments, Inc.
Stewart R. Browne Mfg. Co., Inc.
Calgon, Inc.
Carboline Co.
Cathodic Equipment Co.
Cathodic Protection Service
Centriline Corp.
The Chemical Corp.
Clementina, Ltd.
Coast Paint & Lacquer Co., Inc.
Consolidated Enterprises, Inc.
Crane Co.
M. J. Crose Manufacturing Co.
Crutcher-Rolfs-Cummings, Inc.
The Dampney Co.
Dearborn Chemical Co.
Deadly Chemical Co.
The Dow Chemical Co.
Dowell, Inc.
Dresser Manufacturing Division,
Dresser Industries, Inc.
The Duriron Co.
Eastman Chemical Products, Inc.
Electro Rust-Proofing Corp. (N. J.)
Federated Metals Division,
American Smelting & Refining Co.
Good-All Electric Manufacturing Co.
Gray Co., Inc.
Haynes Stellite Co., A Division of
Union Carbide and Carbon Corp.
Harco Corp.
Hercules Powder Co.
Hill, Hubbell & Co.
Hills-McCanna Co.
Industrial Metal Protectives, Inc.
Insul-Mastic Corp. of America
The International Nickel Co., Inc.
Johns-Manville Sales Corp.

Kansas City Pipe Coating Co.
Koppers Co., Inc.
Ladish Co.
Lebanon Steel Foundry
Lukens Steel Co.
Metallizing Engineering Co., Inc.
Michigan Pipe Co.
Middle West Coating & Supply
Midwest Pipeline Service Co.
Midwestern Engine & Equipment Co.
The Natasco Co.
National Carbon Co., A Division of
Union Carbide and Carbon Corp.
Nelson Electric Manufacturing Co.
The New Jersey Zinc Co.
Nicolet Industries, Inc.
Owens-Corning Fiberglas Corp.
Perrault Equipment Co.
The Pfaudder Co.
The Philip Carey Mfg. Co.
Pipe Line Anode Corp.
Pipeline Coating and Engineering Co.
Pittsburgh Coke & Chemical Co.
Plastic Engineering & Sales Co.
Protective Coatings Corp.
Reilly Tar & Chemical Corp.
Remco Pipeline & Supply Co.
Royston Laboratories, Inc.
Rust-Oleum Corp.
Saran Lined Pipe Co.
Service Engineers, Inc.
Socony Paint Products Co.
The Spee-Flo Sales Corp.
Standard Pipeprotection, Inc.
The D. E. Stearns Co.
U. S. Stoneware Co.
The Tapecoat Co.
Thornhill-Craver Co.
Tnemec Co., Inc.

(Continued on Page 48)



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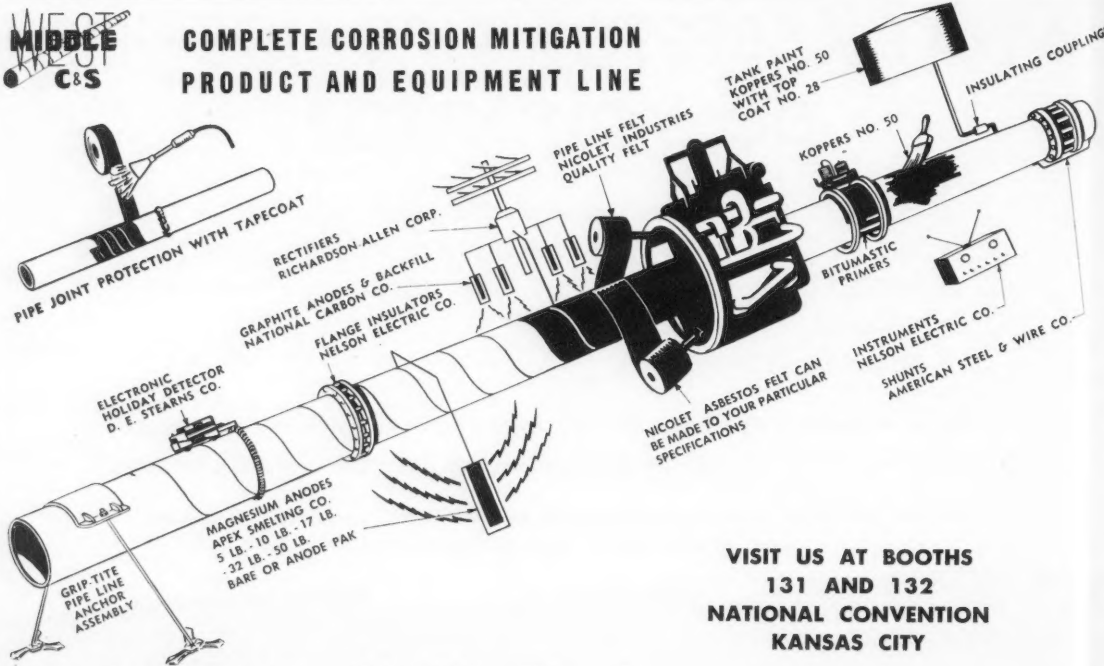


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Barrows Porcelain Enamel Co.
Bart Manufacturing Corp.
A. M. Byers Co.

Brance-Kracy Co., Inc.
Branson Instruments, Inc.
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Carboline Co.
Cathodic Equipment Co.
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The Chemical Corp.
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Coast Paint & Lacquer Co., Inc.
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American Smelting & Refining Co.
Good-All Electric Manufacturing Co.
Gray Co., Inc.
Haynes Stellite Co., A Division of
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Harco Corp.
Hercules Powder Co.
Hill, Hubbell & Co.
Hills-McCanna Co.
Industrial Metal Protectives, Inc.
Insul-Mastic Corp. of America
The International Nickel Co., Inc.
Johns-Manville Sales Corp.

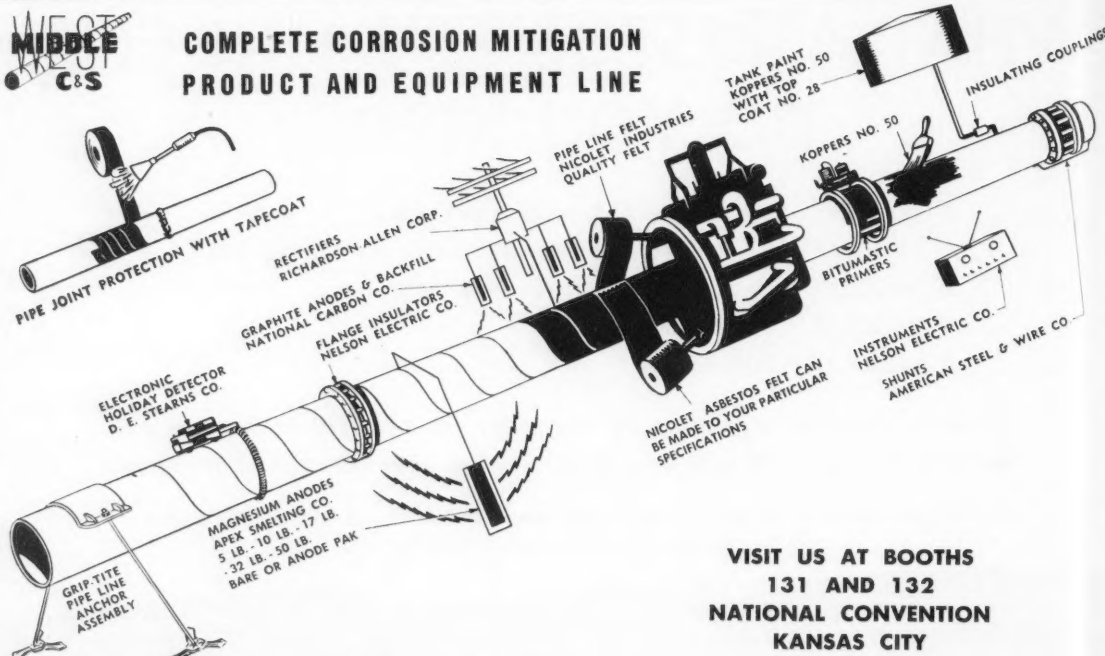
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Midwestern Engine & Equipment Co.
The Natasco Co.
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Union Carbide and Carbon Corp.
Nelson Electric Manufacturing Co.
The New Jersey Zinc Co.
Nicolet Industries, Inc.
Owens-Corning Fiberglas Corp.
Perrault Equipment Co.
The Pfaunder Co.
The Philip Carey Mfg. Co.
Pipe Line Anode Corp.
Pipeline Coating and Engineering Co.
Pittsburgh Coke & Chemical Co.
Plastic Engineering & Sales Co.
Protective Coatings Corp.
Reilly Tar & Chemical Corp.
Remco Pipeline & Supply Co.
Royston Laboratories, Inc.
Rust-Oleum Corp.
Saran Lined Pipe Co.
Service Engineers, Inc.
Socony Paint Products Co.
The Spee-Flo Sales Corp.
Standard Pipeprotection, Inc.
The D. E. Stearns Co.
U. S. Stoneware Co.
The Tapecoat Co.
Thornhill-Craver Co.
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Technical Committee Meetings Scheduled

Monday Morning, March 15, 1954

Committee	Time
TP-1	9-12
TP-2 & 2A	10-12
TP-4	9-12
TP-6G	9-12
TP-6K	9-12
TP-14A	9-12
TP-16A	9-10:30
TP-16B	10:30-11:30
TP-16C	11:30-12:30
TP-18A	9-12

Monday Afternoon, March 15, 1954

TP-1	2-5
TP-5	3:30-5
TP-6A	2-3
TP-6G	1:30-5
TP-7	2-4
TP-13	2-5
TP-14	2-4
TP-15	2-5
TP-15A	1:30-5
TP-16D	1:30-2:30
TP-16E	2:30-3:30
TP-16F	3:30-4:30
TP-16	4:30-5:30
TP-17	2-5

Tuesday Morning, March 16, 1954

TP-1G	9-11:30
TP-1K	9-11:30
TP-3	9-11
TP-6C	9-11:30
TP-6E	9-11:30
TP-6H	9-11:30

Tuesday Afternoon, March 16, 1954

TP-5F	3-5
TP-6B	2-5
TP-8	2-3
TP-18B	2-5
TP-19	12-2
TP6 (Sub-Comm. Chm. & Co-Chm.)	3-5

Wednesday Morning, March 17, 1954

TP-1D	9:30-11:30
TP-1J	9-11:30
TP-5C	9-11:30
TP-9	10-11:30

Wednesday Afternoon, March 17, 1954

TP-1H	2-5
TP-6L	2-5
TP-6M	2-5

Thursday Morning, March 18, 1954

TP-11	9-11:30
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Thursday Afternoon, March 18, 1954

TP-5A	2-5
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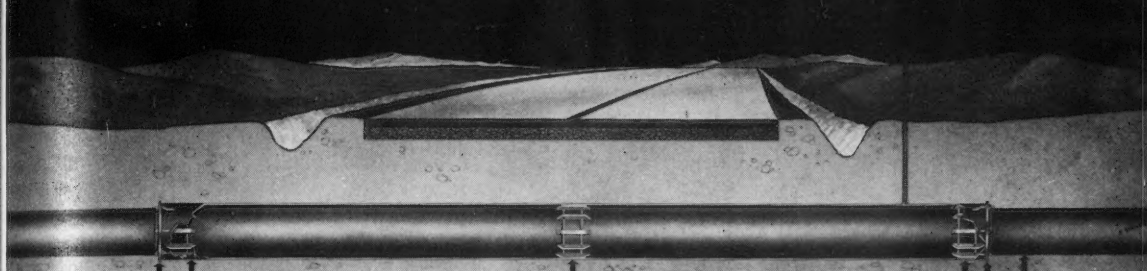
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(Continued From Page 46)

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United States Rubber Co.
T. D. Williamson, Inc.
Wolverine Tube Division,
Calumet & Hecla, Inc.

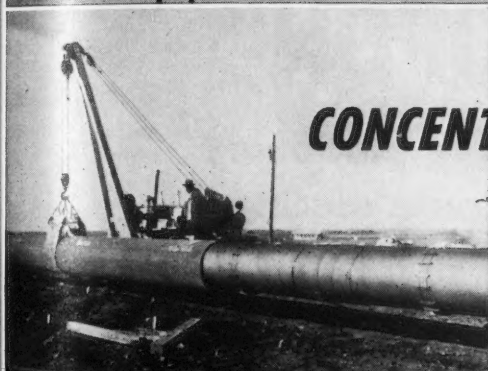
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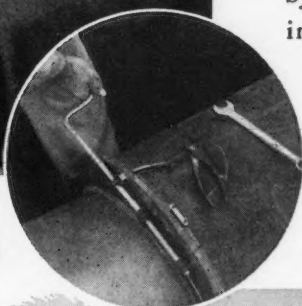
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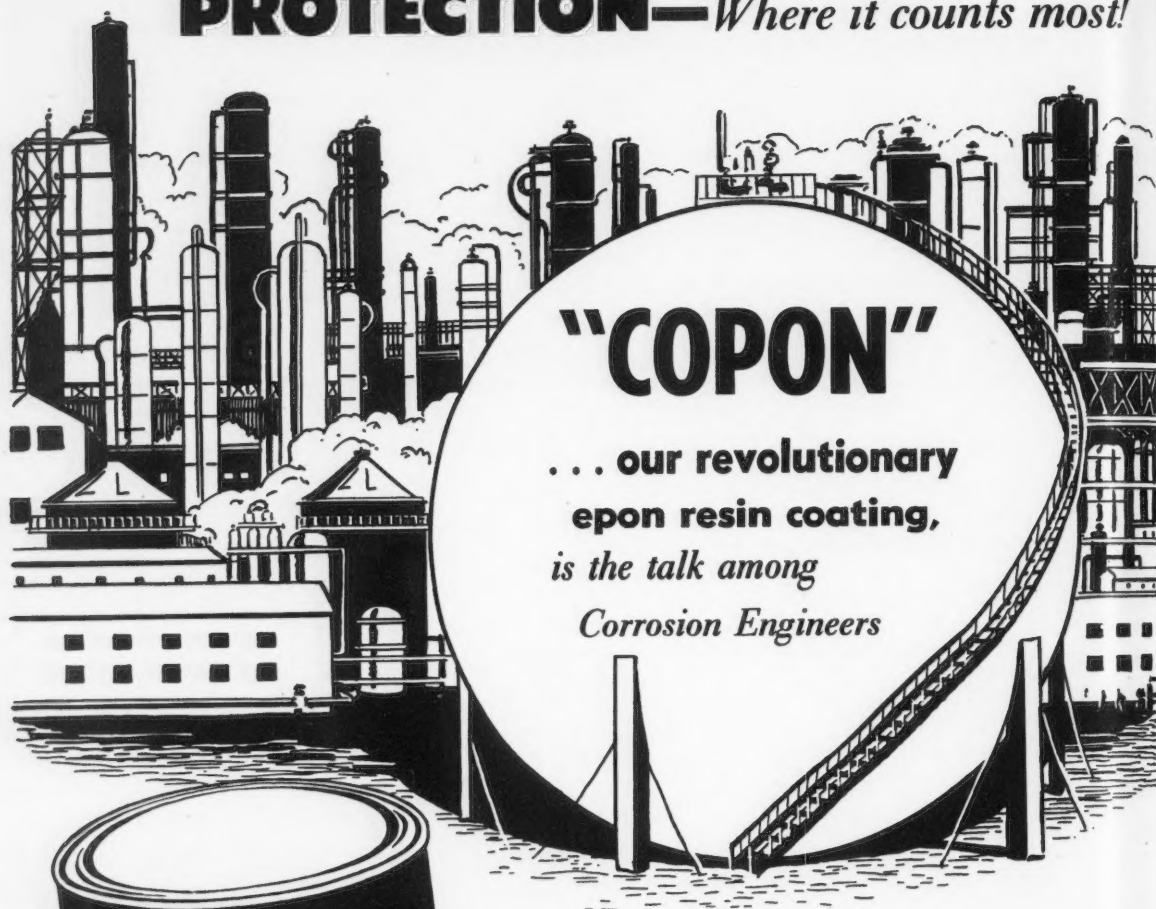
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CORRO

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Corrosion Abstracts

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1. GENERAL

1.3 Reviews

1.3 Corrosion of Metals: An Historical Treatment of the Subject. U. R. EVANS. *Chemistry and Industry*, No. 41, 986-993 (1952) Oct. 11.

A brief survey of the knowledge and theories of corrosion from the earliest times to the present, including corrosion of simple metals, contact corrosion, oxidation, tarnishing, atmospheric corrosion, stress corrosion, corrosion fatigue, water treatment, cathodic protection, and protective coatings. A short bibliography of relevant books is provided.—BNF. 5497

1.5 Directories of Material

1.5 Materials in Design... A Symposium. *Machine Design*, 24, No. 10, 125-160 (1952) Oct.

Copper-Base Alloys, D. K. Crampton; Titanium Alloys, H. A. Jahnle and W. S. Hazelton; Boron Steels, H. B. Knowlton; Rubber and Synthetics, K. P. Goodwin; Magnesium Alloys, J. V. Winkler; Powder Metals, R. Talmage; Plastics, J. Delmonte; Aluminum Alloys, J. W. Willard; Corrosion-Resistant Materials, H. T. Francis; Heat-Resistant Alloys, R. A. Long.

This symposium reports trends and developments in 10 major groups of engineering materials.—INCO. 5534

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 ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Ontario.
 AWWA—Journal, American Water Works Association, Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.
 BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.
 BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.
 BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.
 CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.
 CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.
 CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.
 EL—Electroplating, 83/85 Udney Park Road, Teddington, Middlesex, England.
 EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.
 GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.
 IIM—Transactions, The Indian Institute of Metals, 23-B, Nottaji Subhas Road, P. O. Box 737, Calcutta, India.
 INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.
 IP—Institute of Petroleum. 26 Portland Place, London W#1, England.
 JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chrome Nakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.
 MI—Metallurgia Italiana, Associazione Italiana di Metallurgia, Via S. Paolo, 10, Milano, Italia.
 MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.
 NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.
 NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.
 NSA—Nuclear Science Abstracts, United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.
 PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.
 RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.
 RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.
 RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London, Waldegrave Rd., Teddington, Middlesex.
 SE—Stahl Und Eisen, Verlag Stahlisen, M. B. H., Dusseldorf, August-Thyssen Str. 1. Postcheck Koln 4110, (22a) Dusseldorf, Germany.
 TIME—Transactions of Institute of Marine Engineers. 85 The Minories, London EC 3, England.
 UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.
 ZDA—Zinc Development Association, Lincoln House, Turl Street, Oxford, England.

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1.6 Books

1.6

Corrosion—A Short Course. Book, 148 pp., February, 1952. Dept. of Conf. and Spec. Activities, University Extension, University of California, Los Angeles 24, Cal.

The book consists of 25 lectures given at a Corrosion Short Course at the University of California, Los Angeles, in cooperation with the National Association of Corrosion Engineers, February 4-8, 1952. These lectures, by men active in the corrosion field in the United States, cover such subjects as the Cost of Corrosion and Corrosion Control in the United States, Corrosion of Non-Ferrous Metals, The Soils, Chemical and Physical-Chemical Methods of Applying Coatings to Prevent Corrosion, Theory of Oil Well Corrosion and others. The book is useful for reference and is indicative of the kind of information presented at short courses on this subject. 5849

2. TESTING

2.1 General

2.1.1

Statistical Treatment of Experimental Data. A. LORD. *J. Oil Colour Chemists Assoc.*, 35, No. 387, 437-447 (1952).

Two important statistical techniques, the fitting of regression lines and the analysis of variance, are discussed. The use of a proper estimate of error against which to appraise the effect of a change of an experimental factor or the curvature of an experimental graph, is emphasized. In certain conditions, namely, with equally spaced x values, it is possible to fit curves of high degree, using very simple arithmetic and, what is more, it is possible to decide objectively to what degree the fitting should be carried. In a multifactor experiment the variance analysis be carried out quickly and simply if the factors are used at only two levels. The paper concludes with some notes on statistical textbooks.—RPI. 5537

2.1.1, 2.3.1, 5.4.5

Examples of the Statistical Approach to the Planning and Interpretation of Industrial Experiments. B. SAUNDERS. *J. Oil Colour Chemists Assoc.*, 35, No. 387, 448-458 (1952).

Statistical methods have recently been applied to a wide field of industry, but little reference has so far been made to the oil and color field. Some applications of statistical design to typical experiments of the paint laboratory indicate the superiority of such an approach over the classical method. Experiments describe the use of the Latin Square for studying the wrinkling of a synthetic enamel and a factorial experiment to elucidate the effects of certain factors in the formulation of a stoving finish. A comparison is made between the statistical method of approach and the classical method, emphasizing the quality and amount of information returned in relation to the number of experiments carried out, together with suggestions as to the possible use of these and other designs suitable for use in the type of experimental work required in paint laboratories.—RPI. 5831

2.2 On Location Tests

2.2.3, 7.4.2, 3.5.9

Experimental Superheater for Steam at 200 psi and 1250°F—Progress of Field Operations. F. G. ELY AND F. EBERLE. *Trans. Am. Soc. Mech. Engrs.*, 74, 803-812 (1952) July.

To investigate the properties of new superstrength alloys for high-temperature steam superheater service, a test element constructed of 2-inch outside diameter alloy tubes was installed in an operating boiler at Twin Branch Plant and supplied with steam at 2000 pounds per square inch gage and 950°F., which was heated at 1250°F. Operating conditions, and results of the first 5000 service hours, are described. Croloy 2½, Types 304, 316, 318, 321 and 347 stainless steels, Timken 16-25-6 and Armco 17-14 copper-molybdenum were tested. Internal surface conditions and microstructures of the tubes after test were examined. Illustrated.—BTR. 5517

2.2.3, 8.4.2

Corrosion Tests Simple to Make. *World Oil*, 135, No. 5, 288-290 (1952) Oct.

Evaluation of the chemical corrosion of gas and gas condensate wells is simplified by the use of a special coupon-holder device which is readily installed and removed from the wellhead assembly. This coupon is placed in the flow stream so that it is subjected to the same corrosive environment as other metal parts exposed to the produced stream.—INCO. 5841

2.2.4, 2.4.2, 7.6.6

Digester Corrosion Measurement. NICHOLAS SHOUMATOFF. *TAPPI*, 35, 494-499 (1952) Nov.

Data on sequential wall-thickness measurements, with particular emphasis on quantitative analysis of the data, as an illustration of the study of corrosion in a typical sulfate-pulp digester. Investigation was made of validity of inspection procedure with Audigage thickness tester, of local variations of thickness and corrosion within the vessel, and of best means for interpreting routine inspection data. Tables.—MR. 5774

2.2.6, 6.2.4, 6.2.2

Corrosion of Low-Alloy Irons and Steels in Soils.—(Res. Paper No. 2367). I. A. DENISON AND M. ROMANOFF. *J. Res. Nat. Bur. Standards*, 49, No. 5, 315-324 (1952) Nov. *Corrosion*, 9, No. 4, 141-149 (1953) Apr.

Results of measurements of the corrosion of 10 low-alloy irons and steels exposed to 14 soils for periods up to 13 years are given. The magnitude and progress of corrosion as determined by weight-loss and pit-depth measurements are correlated with the composition of the materials and the nature of the environmental conditions to which the test specimens were exposed. Materials for the tests included open-hearth steel, cobalt-molybdenum open hearth iron, copper-nickel steel, chromium-silicon-copper-phosphorus steel, 2% chromium steel with molybdenum, 4-6% chromium steel, and 4-6% chromium steel with molybdenum. Some nickel is present in all the materials. Table, graphs and 8 references.—INCO. 5486

2.2.6, 6.4.2, 6.3.6, 6.3.8

Tests on the Corrosion of Buried Alu-

minium, Copper, and Lead. P. T. GILBERT AND F. C. PORTER. *Iron Steel Inst. (London)*. Special Report No. 45, 55-74 (1952).

Tubes 15 inches long and 1 inch in diameter and sheets 15 x 10 x ⅛ inch of aluminum (99.5% pure), copper (phosphorus deoxidized arsenical), and lead were buried 2 feet deep in trenches at five sites where the soils were respectively salt marsh, London clay, moist neutral clay, Keuper Marl, and cinders. The results of examination of specimens buried for five years are given. Aluminum was severely attacked in four of the soils, the cinders causing the worst damage, but was virtually unattacked in the moist neutral clay. Copper was severely attacked in the cinders, while attack in the other soils varied from practically nothing in the London clay to moderate attack in the moist neutral clay and Keuper Marl. Lead was practically uncorroded in Keuper Marl and moderately attacked at the other four sites. (Moderate attack indicates pitting through not more than approximately 15% of the wall thickness in five years).—MA. 5633

2.2.8, 5.2.3

Recycling Timer for Interrupting Cathodic Protection Test Currents. D. J. WALDIE. Paper, Pacific Coast Gas Assoc., Fresno, March, 1952. *Pipe Line News*, 24, No. 10, 59-60 (1952) Oct.

A field type instrument for periodically interrupting the test current circuit automatically is described. The instrument consists of a current inverter, a recycling timer and suitable relays assembled in a sheet metal housing. 5842

2.3 Laboratory Methods and Tests

2.3.2

Accelerated Weathering Tests for Exterior Paints. H. RABATE. *Trav. Peinture*, 7, No. 10, 303-304 (1952).

A discussion of the efficacy of accelerated weathering tests, with a note on one cycle employing moist air, U.V., air contaminated with carbon dioxide and sulfur dioxide, high and low temperatures and immersion in sea water. It is recommended that the test be directed towards assessing some one important property of the paint, or again, minor variations in the cycle could be made to examine whether major changes in breakdown rate occur.—RPI. 5734

2.3.2, 2.4.2

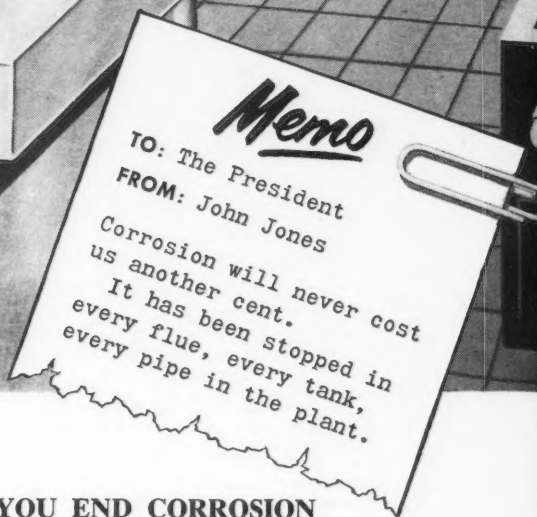
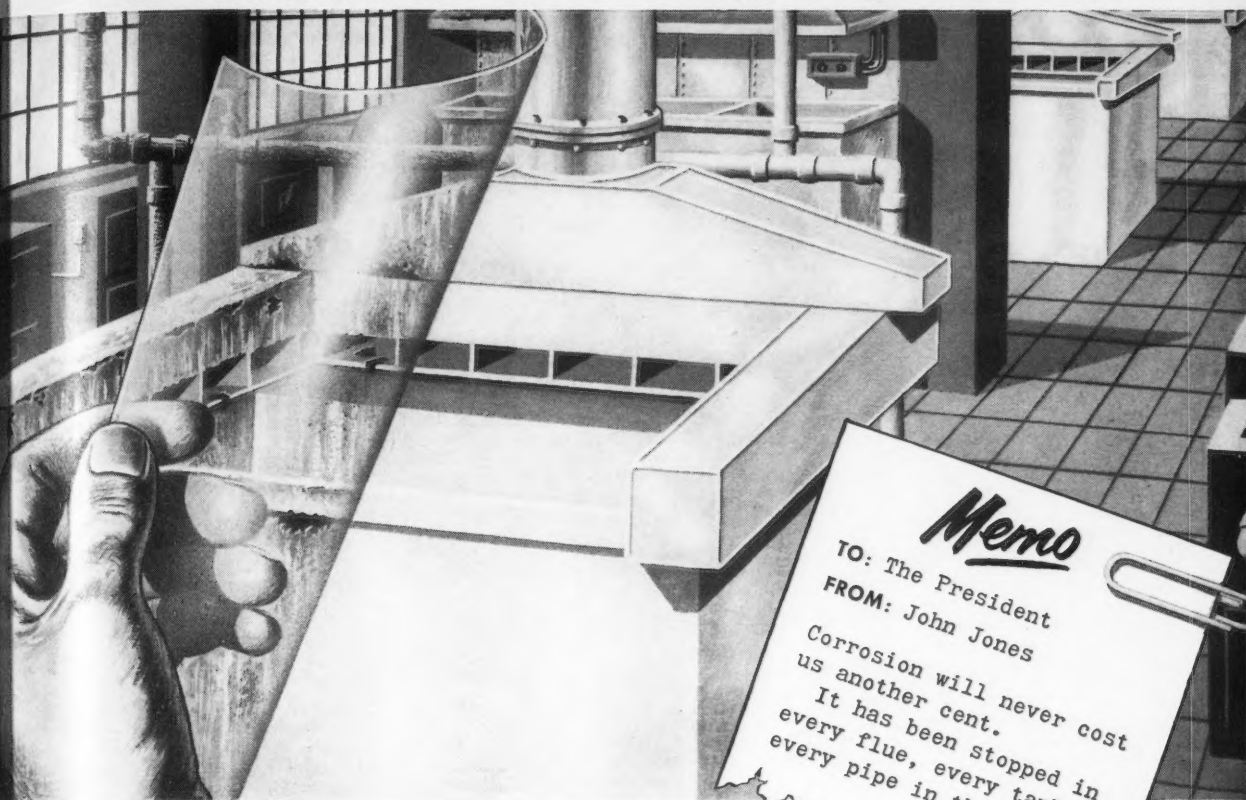
Accelerated Weathering Devices. R.H. SAWYER. *ASTM Bull.*, No. 182, 23 (1952).

Various standing committees of the society have been interested for years in accelerating the changes produced by exposure of materials to weather. The work of these committees has been surveyed and summarized. By far the greatest amount of work has been done on paints, protective coatings and other organic materials subject to extensive weathering change. Rather elaborate mechanical accelerated weathering devices for these materials have been developed and are in extensive use. Careful evaluation of the work of the machines shows them to be controlled weathering devices giving results in a short time but not necessarily comparable with results from actual exterior exposure.—RPI. 5778

2.3.2, 3.2.2

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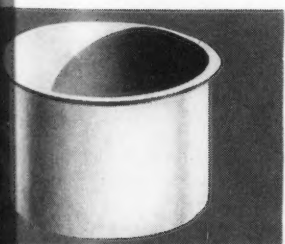
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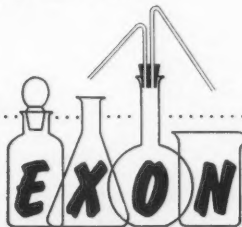


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F. A. PRANGE. *Corrosion*, 8, No. 11, 374 (1952) Nov.

In a solution containing copper sulfate, potassium chloride, sodium acetate and glacial acetic acid in water, uninhibited brass becomes coated with metallic copper or a pinkish-gray deposit, whereas inhibited brass (arsenic, phosphorus, or antimony) becomes coated with a dark gray to black film. An addendum indicates that author finds that a 20% cupric chloride solution behaves just as well as that mentioned above.—BNF. 5743

2.3.2, 3.5.9, 6.5

Report on Performance of Materials Tested in Water At High Temperature. C. J. LANCASTER. U. S. Naval Engineering Experiment Station, Annapolis, Md., Report No. 4A (16) 966870, March, 1952.

In a continuation of the above study, twelve materials were tested in a dynamic corrosion tester. Flat tension specimens were subjected to a static bending stress equal to one-third their tensile strength while being rotated at a peripheral velocity of 11 ft. per sec. in oxygenated water at 500°F. Samples were rated for weight loss and appearance after two consecutive 30-day tests.

All of the stainless steels except Type 347 showed a slight gain in weight for the first 30-day run. For the second 30-day period, all including the Type 347 specimens showed a slight loss. All of the stainless steel samples developed a hard, dark film-like coating during the first run. It remained appreciably unchanged during the second run.

The corrosion resistance in terms of weight loss was satisfactory for a precipitation hardened Armco iron containing about 16% chromium, 4% nickel and 4% copper and for annealed Type 347 stainless steel. However, small pits developed on the faces of both types during the second 30-day run. Each pit was circled by a red discoloration. These red markings also appeared on these and other stainless steel samples at the point of contact with the holder.

The corrosion rate of the 90-10 and 70-30 copper-nickel alloys for the first 30-day run was approximately one-half that of the second 30-day run. During each period a loose powdery scale was formed which, when removed, revealed a hard, dark coating.

Type 304 stainless steel coated with Navy No. 2 babbitt showed a rather high corrosion rate for the first 30 days, the rate for the second period was considerably less. Type 304 samples electroplated with 0.0005-inch gold showed no effect in either run except for a slight gain in weight. Type 304 specimens coated with a silver brazing alloy showed a comparatively high weight loss after a single run.

The corrosion rate of a Duraloy sample was too low to be measured during a single 30-day exposure.—PDA. 5650

2.3.3, 5.4.8

Method of Testing the Effect of Anti-Fouling Paints by Using Artificially Reared Barnacle Larvae. S. TADA. *Official Digest Federation Paint & Varnish Prod. Clubs*, No. 325, 137-142 (1952).

The larvae of the barnacles of *Balanus amphitrite* are reared by feeding the nauplii (hatched in the laboratory) in filtered sea water, with a large amount of artificially cultured marine diatom *Skeletonema costatum*; they molt 7 times

in a week and transform themselves into the cyprid larvae which will readily attach themselves to suitable surfaces within 24 hours and grow into small barnacles. A cylindrical silk bag is placed in a cylindrical glass vessel (35 cm. diam., height 17 cm.) and in the bag are immersed the test panels (8 x 3 x 0.1 cm.), which are made to move slowly (3.5 m/min.) inside the bag. Filtered sea water is made to flow through the vessel at a uniform speed, and the water level is maintained at a constant height. 2000-5000 cyprid larvae are poured into the bag and after 3 days the test panels are removed, and from the number of attached barnacles and their state of metamorphosis, the toxicity of the antifouling paint is estimated. Similar tests may be carried out using larvae of *Bugula* (Bryozoa), *Spirolobis* (Annelida) or *Diplosoma* (Tunicata).—RPI. 5780

2.3.4, 2.4.2

Intermittent-Immersion Type of Corrosion Testing Apparatus. A. INDELLI. *Pittura e vernici*, 8, No. 1, 29-31 (1952).

Details are given of a simple apparatus for testing the corrosion resistance of painted metal panels by intermittently immersing them in corrosive solutions. The panels are hung from a platform above the test solutions and an intermittent dipping motion effected by means of a counterweight repeatedly filled and emptied by a siphon/running tap management.—RPI. 5553

2.3.5, 3.6.5

A Micro-Cell for the Film-Indent Potential Measuring Technique. L. W. GLECKMAN. *J. Electrochem. Soc.*, 99, No. 6, 140C-141C (1952) June.

Original technique for studying the solution potential of a small area of a metal specimen was described by Smith and Pingel (see card No. 1337, coded 2.3.5, 3.6.5). This micro-cell reduces handling of the specimen, etc., and is particularly useful in studying stress-corrosion. 5621

2.3.5, 8.9.3

Testing Anti-Corrosion Coatings by Electrical Measurements. W. WILLING. *Gas u. Wasserfach*, 93, 434-437 (1952) Aug. 1.

The electrical insulation resistance of a number of anti-corrosion protective coatings for underground pipes was measured. The coatings are of three types; those characterized by high adhesivity so that they can be applied to metal without heating, those composed primarily of black bitumen which must be heated to be applied and those consisting of bitumen with an adhesive layer so that it can be applied without heat. The data are presented in graphs. 5815

2.3.6

The Electron Microscope in Metallurgy. (In German). HANS MAHL. *Metall*, 6, 69-73 (1952) Feb.

Principal electron microscopic methods of studying the surfaces of metals. Electron micrographs and diagrams, 25 references.—MR. 5520

2.3.6, 4.4.6

A Modified Method for the Estimation of Corrosion Due to the Free Sulfur and Sulfur Compounds in Oils. R. A. PATTON and J. H. LIEBLICH. *ASTM Bull.*, No. 186, 59-66 (1952) Dec.

The optical phenomena involved are

examined in detail to permit an estimation of the reliability of the present procedure of visual examination. A modified procedure is described and an appraisal of its merit outlined. A direct comparison of the two procedures is set forth. Illustrations and references.—INCO. 5675

2.3.7 Influence of Stress and Temperature in Stress-Corrosion Experiments. (In German). OTTO LISSNER. *Z. Metallkunde*, 43, 147-150 (1952) May.

Discusses the justification for the plotting of log-log coordinates for stress dependence of life duration of test pieces exposed to stress-corrosion. Temperature dependence and permissible temperature increase in stress-corrosion experiments are indicated. Data are charted for steels and aluminum alloys. 14 references.—BTR. 5631

2.3.7, 5.3.2, 2.4.3

Testing Porosity in Plated Coatings. A. KUTZELNIG. *Metal Ind.* (London), 81, No. 5, 89 (1952) Aug. 1.

Better test method which shows up the pores in the nickel coating on steel has been developed. A reaction paper impregnated with alpha-nitroso-beta-naphthol is moistened with water and placed on the surface to be tested. The pores in nickel or tin plated coatings show up as bluish-green spots. Organic reagents can be usefully employed for testing pores in other plated metals.—INCO. 5601

2.3.7, 5.6.3

The Simultaneous Measurement of Oxygen and Carbon Dioxide Permeabilities of Packaging Materials. A. H. LANDROCK and B. E. PROCTOR. *TAPPI*, 35, 241-246 (1952) June.

A method for measuring the above based on Dalton's law of partial pressures, is described. The test sheet is mounted between two chambers, the lower containing nitrogen and the upper swept with a mixture of oxygen and carbon dioxide. Apparatus diagrams, graphs and tables, 18 references.—BTR. 5580

2.3.7, 7.1

Evaluation of Wear in Diesel Engines by Means of Accelerated Tests. R. E. KENNEMER. Caterpillar Tractor Co. Paper before SAE, Western Mich. Section, Muskegon, Oct. 6, 1952. *SAE Journal*, 60, No. 5, 50-53 (1952) May.

Accelerated wear tests for evaluating the effects on engine wear of several variables in a reasonable length of time and at a practical cost include the following types: Abrasive wear, corrosive wear and scuffing tests. The dust feeder for the abrasive wear tests has a rotating carrier with four stainless steel wipers. Aluminum bearings were also used for this test. Testing procedures and types of engines used are given. Illustrations.—INCO. 5602

2.3.7, 7.7, 6.3.6

Tests on the Tinning of Copper Wires. H. MEISWINKEL. *Werkstoffe u. Korrosion*, 3, No. 9, 355-357 (1952) Sept./Oct.

Copper conductor wires which are covered with rubber insulation must first be tinned with a nonporous tin coating. This prevents corrosive action by the rubber on the copper. Various chemical methods are available for gauging the thickness and porosity of the coating. It can be dissolved by a weak solution of iron chloride. The better

method of testing the porosity is to dip the tinned wire in a solution of ammonium persulfate. Any pores or weak places will cause the solution to turn blue. The intensity of the blue color is measured by a photometer or a colorimeter, thereby giving an indication of the amount of copper dissolved. The protective value of the tin coating is then ascertained by constructing curves and comparing the difference between coated and bare wires.—INCO. 5536

2.3.9

Use of Ultrasonic Waves for Internal Flaw Detection. *Industry and Welding*, 25, 60, 62 (1952) Aug.

The Ultrasonoscope of Glass Developments Ltd., London. By using a persistent screen cathode-ray tube and causing the echoes to brighten the trace instead of deflecting it, an "ultrasonic image" is produced which can be examined and interpreted like a radiograph. Claimed to be of special value in weld testing.—MR. 5545

2.3.9

Autoradiography of Metal Surfaces Using a Radiochemical Method. E. RABINOWICZ. *Nature*, 170, 1029-1030 (1952) Dec. 13.

The different chemical reactivities of the various metal surface components toward some labeled substance that forms a localized radioactive product can be used as a surface-autoradiographic technique. The method is illustrated by applications of ^{131}I -labeled amyl iodide to numerous metals, the number of atomic layers formed by reaction of the iodine with the metal being determined. A surface autoradiograph of a steel surface showing location of copper fragments transferred during sliding is shown. Good resolution and flexibility feature the method.—NSA. 5741

2.4 Instrumentation

2.4.2, 2.3.2

Highlights—Testing. *Product Eng.*, 23, No. 12, 9 (1952) Dec.

Salt spray tester for all ferrous and non-ferrous metals and organic and inorganic coatings was announced by Singleton Co. It is inert to all solutions and gases used in the complete range of testing. The unit's atomizer operates from any plant air system and the heater from a 110-volt line.—INCO. 5666

2.4.3, 2.3.9, 7.2

Ultrasonic Testing of Small-Diameter Tubing. A. J. PARDUS. Knolls Atomic Power Lab. Feb. 1, 1952. Decl. Dec. 16, 1952. 30 pp.

With the development of the procedure and equipment outlined in this report, ultrasonics can be applied successfully to locate flaws in 0.060-in. ID x 0.080-in. OD tubing. By means of high-frequency pulsating sound waves sent into the tubing to be tested, flaws are located by reflection of the sound waves from the defect. Any discontinuity, as well as the opposite end of the tubing, will reflect the wave back to the searching unit which presents it to the reflectoscope. In the testing of thin-walled tubing, a shear wave is generated by an angle quartz crystal and is sent angularly into the tubing being tested. Best results were obtained with a 1-Mc, 1-in. quartz-crystal, angle-searching unit.

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Higher-frequency crystals, $2\frac{1}{4}$ and 5 Mc, were also tried but were unsuccessful due to high attenuation of the sonic energy. Prior to the development of this procedure, no satisfactory means of detecting and measuring defects in small-diameter, thin-walled tubing had been available.—NSA. 5672

2.4.3, 2.3.9

For Faster Non-Destructive Testing: Semi-Automatic X-Ray Equipment. DAVID GOODMAN. *Am. Foundryman*, 22, 62-63 (1952) Aug.

Use of semi-automatic X-ray units coupled with automatic film developers makes speed and quality compatible.—MR. 5496

2.4.3

Radioactive Cobalt Detects Steel Defects. *Machine Design*, 24, No. 7, 108 (1952) July.

Among the first practical industrial applications for nuclear fission is the examination of steel castings for internal defects with radioactive cobalt. When used with photographic film, the rays produce a picture of any defects in the steel. The gamma rays are capable of penetrating steel from $\frac{1}{2}$ to 6 inches thick.—INCO. 5526

2.4.3, 2.3.9

Ultrasonic Thickness Testing. *Marine Eng. and Shipping Rev*, 57, 138 (1952) Oct.

The great economy, speed and convenience of non-destructive thickness measurements by the ultrasonic thickness tester can be materially increased under awkward conditions by the use of a new magnetic fixture to hold the searching unit against the plate being tested. This valuable accessory assures good contact and prevents accidental shifting of the searching unit during tests and permits one man to operate the instrument alone in different locations. It is particularly valuable when working on ladders or staging and when test points are beyond easy reach, such as ship hulls and upper plates of bulkheads. The fixture consists of a flat spring with an Alnico permanent magnet coupled flexibly to each end and means for attaching the searching unit quickly and easily to its center. The standard magnets are of sufficient strength to hold the unit properly against surfaces that are slightly irregular or covered with a thin coat of paint. Heavier magnets can be provided for use on cast iron and other rough surfaces or on plates that are covered with thick coatings of paint or scale.—TIME. 5539

2.4.3

Fluorescent Ink as an Inspection Tool. *Light Metals* (England), 15, 234-235 (1952) July.

Use of Glo-Mor fluorescent ink for nondestructive testing.—MR. 5588

2.4.3

H-2 Research A. J. MACEDO. *Aviation Week*, 57, No. 11, 56, 58 (1952) Sept. 15.

Talao's experiments with H-2 were prompted by a cock-pit hydraulic leak. Use of the non-flammable fluid, H-2, showed no leakage nor any appreciable corrosion. Minor surface corrosion was observed at the bore of the aluminum housing. All steel parts are coated with PR-611 as protection against corrosion. INCO. 5610

2.4a

2.4.3, 2.3.9

New Ultrasonic Flaw Detector. *Ship-builder and Marine Engine-Builder*, 59, 367-368 (1952) May.

A new design of ultrasonic flaw detector, utilizing the single-probe principle has recently been introduced. This new unit employs only one crystal, which acts as both transmitter and receiver of the ultrasonic vibrations. These ultrasonic vibrations are produced by high-frequency electrical currents, which cause the crystal to vibrate. They are transmitted to the material which is being tested, by direct contact with the crystal. They travel through the material at speeds depending on the nature of the material and they suffer only small loss of energy in the process. They can, therefore, travel long distances in a homogeneous object. If, however, they encounter a discontinuity, such as a crack, porosity, a foreign inclusion, or a juncture of two surfaces (e.g., metal to air at the end of the object, or metal to metal in between, even if these surfaces are optically plane), the vibrations are reflected and only a very small portion of their energy passes on. The echoes so produced are received by the crystal on their return, and they are reconverted into electrical impulses, which are registered on a cathode-ray oscillograph. This oscillograph then indicates two or more peaks in the scanning trace. The first is produced when the transmitted wave enters the object (initial pulse), the second arises from the wave which is reflected from the far end (the bottom echo), while others, if present, are caused by the discontinuity of defect which is in between. The distances between these peaks on the oscillograph screen are a measure of the position of the discontinuity or of the metal face remote from the crystal. The field for this form of non-destructive testing is large. Machined parts, forgings and welded joints can be examined for the presence of cracks, slag inclusions, porosity, welding defects, laminations and so on. The operator, in addition, is able to measure the thickness of objects in which inaccessibility makes direct measurement impossible (e.g., pressure vessels, long pipes or boilers, etc., which may have become subject to corrosion). For those applications where a double probe is more convenient, facilities are provided for their use, either as separate transmitter and receiver, or as double transceivers. Facilities for photographing the screen of the cathode-ray tube are built into the instrument and thus a permanent record may be kept.—TIME. 5817

2.4.3

A New Method for Production of Paper Records in Non-Destructive Tests of Surface Defects in Products. (In German). W. STAUFFER AND A. KELLER. *Schweiz. Arch. angew. Wiss. u. Tech*, 18, No. 5, 137-148 (1952) May.

This, the so-called "lacquer skin" method, makes use of a transparent lacquer as a base, which when applied to the surface takes up indications of the defects and retains them on drying. Applicable both to magnetic and liquid penetrant methods. Also serves to "fix" the defect-records on the product and as a developer in the liquid penetrant method. The "lacquer skin" record can be treated as a negative for production of photographic copies.—BNF. 5776

2.6 Preparation and Cleaning of Specimens

2.6, 3.2.3

The Isolation and Examination of Films from Metal Surfaces: An Improved Technique. T. J. NURSE AND F. WORMWELL. *J. Applied Chem.* (London) 2, Pt. 9, 550-554 (1952) Sept.

Improved technique for the removal of oxide films from metal surfaces entails the reinforcement of the film by Formvar (polyvinylformal) resin. The technique and applications of the method are given. Films on mild steel, 18% chromium-nickel stainless steel and on non-ferrous metals including nickel were examined. 10 references.—INCO. 5661

3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2, 6.2.2

Role of Thermal, Mechanical, and Surface Treatments in the Cathodic Charging of Iron With Hydrogen. (In French). JEAN DUFLLOT. *Rev. met.*, 49, 35-50 (1952) Jan.

Permeability of Armco iron for hydrogen at room temperature, solubility of hydrogen in iron, the iron-hydrogen equilibrium and the behavior of iron when its hydrogen content is as large as possible. Apparatus is diagrammed. Results are tabulated, charted and illustrated by micrographs.—MR. 5705

3.2.2, 6.4.2

A Metallographic Study of Pitting Corrosion Induced in 2S Aluminum Alloy By Exposure to Tap Water. E. C. PEARSON, H. J. HUFF, AND R. H. HAY. *Can. J. Technol.*, 30, No. 10/11, 311-316 (1952) Oct.-Nov.

Samples of 2S aluminum alloy, in both the fully work-hardened and the annealed state, have been examined under the conventional light microscope and the electron microscope after exposure to pitting corrosion conditions in tap water for periods of 15 min., 24 hr. and 10 weeks. Prior to exposure all sample panels received a uniform pre-treatment designed to bring panel surfaces into the same initial condition. Typical photomicrographs are presented to show the variation observed in pit structure with time of exposure and with metallurgical condition. Electron stereomicrographs of the 15-min. pits and of the 10-week pits reveal new and interesting characteristics of the pit structure.—ALL. 5681

3.2.2, 6.3.19, 3.7.4

Inter-crystalline Corrosion in Cast Zinc-Aluminum Alloys. C. W. ROBERTS. *J. Inst. Metals*, 81, No. 6, 301-309 (1953) 1953).

To determine the susceptibility of zinc-aluminum alloys to inter-crystalline corrosion in an air/water-vapor atmosphere at 95°C and to examine the effect of the presence of other elements on the incidence of this form of corrosion, alloys of various composition within the range aluminum 0-22, copper 0-1.5, magnesium 0-0.09, lead, tin and cadmium 0-0.030, bismuth 0-0.016, and manganese 0-0.050% were prepared and tested in the as-cast condition. The main conclusions

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sions drawn from the work are that: 1) intercrystalline corrosion is confined to the α (zinc-rich) phase, although attack is more severe when the β (aluminum-rich) phase is also present, as a result of the larger surface area of the α grains in the two-phase alloys; 2) the severity of attack is greatly increased by the presence of small percentages of lead, tin, cadmium and bismuth; 3) the addition of a small amount of magnesium greatly reduces the severity of the corrosion, whether impurities are present or not, provided conditions are such that intermetallic compounds of magnesium with the impurity elements are not formed; and 4) the presence of copper increases the resistance of two-phase alloys to intercrystalline attack. The results of the present investigation and those published by other investigators are discussed, and tentative theories are put forward to explain certain aspects of the phenomenon.—MA. 5735

3.2.2, 5.3.4

Note on Embrittlement From Alkaline Tin Plating. C. A. ZAPFFE and M. E. HASLEM. *Plating*, 39, No. 5, 468-469, 485 (1952) May.

In the June, 1950, issue of *Plating**, a research was described in which hydrogen absorption by a steel cathode during electroplating was measured in terms of the embrittlement manifesting itself in a special bend test. The data for the alkaline bath have since been called in question. The procedure used in the research did not take advantage of recent recommendations of the Tin Research Institute. The research was extended to include the recommendations of the TRI. The results for stainless steel and carbon steels are discussed. It was found that there is no significant difference between the previous test and TRI baths so far as hydrogen embrittlement of the basis metal is concerned. Tables are given.—INCO. * (See NACE Abstract Card No. 2939, classified 3.2.2, 5.3.4, 6.3.10, 6.3.14, 6.3.8). 5799

3.2.2, 6.4.2, 3.7.4, 3.5.8

Structure and Corrosion of Aluminum-Magnesium and Aluminum-Titanium-Magnesium Alloys. Part II. PIERRE A. JACQUET. *Rev. Met.*, 49, No. 6, 439-452 (1952).

The structure and corrosion of the high-resistance aluminum-zinc-magnesium alloys, T60, Zical and 75S, were studied. The first two alloys are difficult owing to the maldistribution of the chromium. The relation between tendency to corrosion and structure is more complicated than in the binary alloys. The thermal treatment that makes AG7 sensitive to corrosion stabilizes Zical. Micrographically the two types of alloy are also different. In the annealed state after quenching, Zical is immunized against intergranular corrosion and its potential is more noble than that of quenched AG7. The formation of free hydrochloric acid on the anodes of local couples of annealed AG7 suggests a new mechanism of corrosion of aluminum-rich alloys. This mechanism involves a chain reaction of a catalytic character based on the hydrolysis of aluminum chloride and explains the special action of hydrochloric acid among the mineral acids where such a reaction cannot take place because of the low solubilities or degrees of dissociation. This mechanism accounts for all the known facts of stress-corrosion, which is only a particular case of intergranular corrosion. 36 references.—MA. 5635

3.4 Chemical Effects

3.4.9, 6.4.2

On the Resistance to Corrosion of Aluminum and Its Alloys in Steam. M. MATSUDA. *Light Metals* (Japan), No. 5, 109-112 (1952) Nov.

Tests were made on commercial aluminum alloys (to determine resistance to corrosion in the containing steam) measuring weight loss, decrease in tensile strength and elongation. 1). As compared with iron, aluminum and its alloys were found to have high resistance in steam. 2). High-purity aluminum, under steaming atmospheres, was superior to the other aluminum and alloys in resistance to corrosion. This resistance increased with purity. The effects of a few impurities, iron and copper, on the resistance to corrosion should be considered. 3). Unexpectedly, the resistance of 52S is less than that of high-purity aluminum.—JSPS. 5638

3.5 Physical and Mechanical Effects

3.5.3

Gear Tooth Wear. G. I. FINCH and R. T. SPURR. *J. Inst. Petroleum*, 38, 623-624 (1952) Aug.

The engagement of the load-bearing areas in the gear assembly may be regarded as compounded of rolling and sliding motions. It is well known that, when two clean metallic surfaces are brought into contact, cohesion occurs across the interface and causes them to seize together. In practice, however, bearing surfaces are covered with thin films of oxidation products, adsorbed gases and vapors and lubricant molecules and it is between these films that contact occurs. The cohesive forces between such layers are small compared with the forces between the atoms in the bulk of the metal; hence, on parting the surfaces, separation occurs relatively easily within these non-metallic layers. But if the loading intensity is sufficiently high to cause such deformation of the underlying metal that the surface layers become stretched and ruptured so that metal is exposed, intermetallic contact and strong cohesion may ensue. It is evident, therefore, that in this case resistance to seizure is not primarily determined by the properties of the surface layers, but is related to the ability of the underlying metal to resist deformation and hence to support these layers. Consequently, surfaces which are pressed together without shear to a high loading intensity should consist of metals of high rigidities. Some measure of shear, which can be intermittent, may, however, occur between the surfaces, owing to elastic deformation and hysteresis in elastic recovery. In the pitch-line region of the gear-tooth, where the rolling is between surfaces of similar curvature, elastic deformation should not result in shear, provided the surfaces have the same rigidity. When a critical load intensity is exceeded the surfaces may rumple, or suffer fatigue failure after repeated application of the load. The severity of conditions is accentuated when the purely rolling mechanism of progressive load transfer from one region to another of the mating surfaces is accompanied by sliding shear. It now becomes possible for any boundary lu-

bricant film to be sheared or rubbed away to expose the oxide layers. These in turn may become disrupted and give rise to compacted particles of debris which become foci of excessive loading intensity leading to plastic deformation of the underlying metal and possible local seizure. Once formed, such a weld tends to increase in extent as a result of the sliding motion. Failure will usually occur within the bulk of one surface, so that a fragment of metal will be torn out of one surface and left adhering to the other. This fragment will then score and tend to seize again to the surface sliding past it, and so the damage becomes progressively worse.—TIME. 5566

3.5.3

High-Wear Resistance Materials. *Engrs. Digest*, 13, 285-286 (1952) Sept.

In spite of its utmost importance in engineering problems, a better understanding of the real mechanism of the wear of metals is still lacking. In fact, the vast mass of empirical data extant has resulted in a number of unrelated and even conflicting statements, some true, some half-true, some perhaps not true at all. Logical approach to the problem leads to the conclusion that the ability of a surface to deflect out of the way of asperities on a moving mating surface or foreign particles and to spring back again seems to be important in wear resistance. Large amounts of elastic deflection may be achieved by the selection of a material which has high strength and hardness and a low modulus of elasticity. This desirable combination of properties does not commonly occur in metals, but both the elastic limit and the modulus of elasticity of metals can be controlled within certain limits. Thus, there exists for the future considerable latitude in increasing the total elastic deflexion of metals or related materials with a view to increasing their wear resistance. The correctness of this concept of wear resistance is borne out by the fact that materials which are normally considered abrasive possess excellent wear resistance. This has been proved by tests conducted on cylinder liners of aluminum. In addition to freedom from liner wear, the wear rate of the piston rings was also found to be greatly reduced. With economical methods of manufacturing alumina wearing surfaces, this material may therefore become generally accepted for this and other purposes.—TIME. 5565

3.5.8, 6.3.6

New Copper Alloy Has High Stress-Corrosion Resistance. C. H. HANNON. *Gen. Elec. Co. Iron Age*, 170, No. 21, 131-133 (1952) Nov. 20.

New copper-nickel-silicon alloy (Strenicor) developed shows high resistance to stress-corrosion failure. Addition of critical amounts of iron to the alloy gave improved properties. While excellent properties are found in sand cast and hot-forged parts, highest mechanical properties are developed by successive solution and aging heat treatments. Composition range of 3.5-5% nickel, 0.7-2% silicon, 0.3-1% iron and the balance copper is given.—INCO. 5505

3.5.8, 5.8.2, 7.6.4

Caustic Cracking in Water Tube Boilers with Riveted Drums. R. L. REES. Paper before Soc. of Chem. Ind., Corrosion Group, Nov. 20, 1952. *Chemistry*

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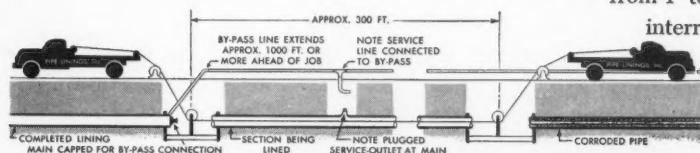
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& Industry, No. 50, 1213-1216 (1952) Dec. 13.

General view of caustic cracking, methods of prevention and the embrittlement detector are discussed. Use of sulfate should be continued in the hope of blocking leakage paths, nitrate being used simultaneously as an inhibitor. Nitrate treatment is the most effective of all known methods of preventing caustic cracking in practice. However, there is the possibility that the protective power of nitrate may be destroyed by chemical reduction in the boiler. More knowledge is required about the degree of protection that can be gained with phosphate and the circumstances in which it is effective. References.—INCO. 5787

3.5.8, 7.6.4

Caustic Embrittlement in Boilers Cracking Investigated at High Magnification. H. M. SPRING, JR. AND J. G. SYLVESTER. Mutual Boiler and Machinery Insurance Co. *Southern Power and Ind.*, 70, No. 12, 72-73 (1952) Dec.

Series of photomicrographs at 2000x showing initial or embryo stages of the embrittlement crack. Object of investigation was to reveal the path and progress of embrittlement cracking. The theory that the polarity existing between the disordered atomic structure of grain boundaries and the orderly lattice structure of the grains under proper conditions of stress and sodium hydroxide concentration resulting in a flow of ions from the electropositive grain boundaries into solution is discussed.—INCO. 5792

3.5.8, 5.10

Grease Feedability Reduces Fretting Corrosion. *Aviation Age*, 18, 6-16 (1952) Sept.

A study of effect of soap base, consistency, and additives on minimizing fretting corrosion. Lithium, sodium, sodium-calcium, and calcium soaps were used on ball thrust bearings in a special friction oxidation tester. Includes literature survey. Tables and photographs. 20 references.—BTR. 5430

3.5.9, 6.1

Metals in the Jetomic Age. ALLEN G. GRAY. *Steel*, 131, 148-153 (1952) Oct. 13.

Discusses four different types of materials for ultra-high-temperature service: metals and alloys, metals protected with ceramic coatings, ceramic materials, and combinations of metals and ceramics. Photographs and graphs. 12 references.—BTR. 5456

3.5.9, 6.6.6

Corrosion of Refractory Materials. H. TOWERS. *Ber. Deut. keram. Ges.*, 29, No. 4 (1952). *Blast Furnace & Steel Plant*, 40, No. 8, 921-925, 927 (1952) Aug.

Summary of some of the contributions to the field of refractory during 1940-1950. Much work was devoted to the problem of increasing the resistance of refractory materials to slag attack. The primary factor is chemical and is a function of the chemical and mineralogical composition of the brick, the slag and the possible reaction products, i.e. of the constitutional diagrams of the system involved. The rate of attack can be affected by operating conditions such as temperature, the amount and method of presentation of the slag to the brick, the oxidizing potential of the furnace atmosphere and furnace contours. Various examples are given of the type of attack

and the inclusions formed between slag and the refractory.—INCO. 5797

3.5.9, 7.1

A Survey of High-Temperature Materials. J. M. ROBERTSON. *Metal Treatment*, 19, No. 81 & 82; 275-283, 303-312 (1952) June, July.

A survey of high-temperature materials for the use of metals at high temperatures in steam and gas turbines is given. Precipitation hardening, high-temperature mechanical properties, effect of heating and cooling cycles, reactions between metals and environments, protective films, graphitization, treatment of austenitic steels, the sigma phase, warm working or hot-cold working and conservation of materials are discussed. Among the alloys discussed, with reference to constitutional and structural changes that influence their treatment and behavior, are low alloy, carbon-molybdenum, chromium-molybdenum, mild, ferritic vanadium, carbon, bolt, oxidation resisting ferritic, austenitic steels; nickel and cobalt base alloys and ferritic steel containing molybdenum and vanadium. Graphs and photographs, including one of a gas turbine blade forging in Nimonic 90 are included. Compositions of representative alloys used for stressed parts in the range of temperature 450-950°C, giving nickel content, are tabulated.—INCO. 5733

3.5.9, 3.4.9

Effect of Temperature on Corrosion of Metals by Water. NORMAN HACKERMAN. *Ind. and Eng. Chem.*, 44, 1752-1755 (1952) Aug.

The influence of systemic temperatures and of temperature gradients on rates and distribution of corrosion reactions is considered, especially for the case of water. A general prognosis of temperature effects cannot be made as a guide for all systems because of the variety of influences that temperature has on the several components of a corrosion system. Explanation of observed effects and perhaps prediction, is made possible by systematic consideration of the way in which each unit responds to temperature change. A few of the important temperature-dependent properties discussed are oxygen solubility, galvanic potentials and precipitation rates.—NSA. 5504

3.5.9, 6.2.5, 3.7.3

Austenitic Cast Stainless Good for Low Temperature Applications. But. J. W. JUPPENLATZ. *Iron Age*, 170, 147-151 (1952) Sept. 4.

Shows that full austenitic structure or low magnetic permeability is not a guarantee of high impact strengths at low temperatures. Although welding of some grades does not seriously affect low-temperature properties, postweld solution treatment is shown to be advisable for improved corrosion resistance. Comparative mechanical properties are charted.—BTR. 5639

3.5.9, 6.7.2

Powder Metallurgy for High Temperature Applications. J. J. HARWOOD. Metallurgy Branch, Off. Nav. Res. Paper before Metal Powder Assoc., 8th Ann. Mtg., Chicago, April 29-30, 1952. *Proc. Metal Powder Assoc.*, 1952, 35-50; disc. 51-52; *Materials & Methods*, 36, 87-91 (1952) Aug.

Discussion of contributions of powder metallurgy to the solution of problems

in high temperature materials. The application of these materials in gas turbines is considered. Three different approaches to the problem are the development of cermets, of sweat cooled blades, and of molybdenum-base alloys. A Swiss development of a strong high temperature aluminum alloy called SAP, and produced by the Hametag process, shows potentialities for use at temperatures of 800°F. Varieties of metal-bonded titanium carbide compositions, developed by Kennametal, Inc., employ a nickel binder and are being marketed as Kestanium K151A and K152B. K151A contains 20% nickel as a binder and mixed solid solution carbides of tantalum-niobium. K152B also contains tantalum-niobium carbides and has a binder content of 30% nickel. A graph showing stress-rupture properties at 1800°F of titanium carbide using chromium-nickel or chromium-cobalt binders is given. Copper, nickel and stainless steel cylindrical ducts were made by powder metallurgy techniques for use in sweat cooling systems. Tables, graphs and 11 references are included.—INCO. 5506

3.5.9, 3.4.6

High Temperature Corrosion Rates of Several Metals with Hydrogen Sulfide and Sulfur Dioxide. M. FARBER AND D. M. EHRENBURG. California Institute of Technology. *J. Electrochem. Soc.*, 99, No. 10, 427-434 (1952) Oct.

Corrosion rates at temperatures above 1000°K were determined for several metals including copper, silver, Inconel, nickel, 18-8 steel, iron, tungsten, molybdenum and tantalum in atmospheres of hydrogen sulfide, sulfur dioxide, carbon monoxide. This was done by increase in electrical resistance of the metals in the form of filaments 0.001 inch in diameter. The metals most easily corroded in hydrogen sulfide were Inconel, iron, copper and stainless steel, whereas tungsten, molybdenum, and tantalum offered the most resistance. Inconel is very resistant to sulfur dioxide, whereas tungsten, tantalum, and molybdenum are easily corroded. Carbon monoxide increases the corrosion rate of nickel in hydrogen sulfide, whereas the corrosion rate of iron is decreased in the presence of carbon monoxide. Illustrations and references.—INCO. 5506

3.6 Electrochemical Effects

3.6.1, 5.1

How the Maintenance Man Can Reduce Corrosion Costs. H. H. ANDERSON. Shell Pipe Line Corp. *Southern Power and Ind.*, 70, No. 5, 102-104 (1952) May.

Tips on corrosion detection, prevention and remedy for the maintenance man are given. A discussion on corrosion sources includes situations which create electro-chemical corrosion such as different concentration of the same chemical in adjoining parts, e.g. a steel water tank where the metal rusts near the surface of water and remains bright near the bottom. Preventive methods are installing cathodic protection and electric bonds between dissimilar parts, making the machine part from a baser metal by coating steel or iron parts with zinc, aluminum, chromium or other non-ferrous metals, or from a nobler metal such as lead, nickel, tin or copper and stress

relieving. Changing the condition of the gas or liquid and of its flow are other methods. Protective coatings are considered.—INCO. 5322

3.6.2

Incipient Corrosion of Steel: Study of Its Initiation and Progress. F. HARGREAVES. *Metal Treatment and Drop Forging*, 19, 385-390 (1952) Sept.

Study in which filiform corrosion was induced in a polished steel specimen and its growth traced. Effect of non-metallic inclusions and droplets of various liquids and influence of surface protectives were also studied. Micrographs.—BTR. 5727

3.6.2

Filiform Corrosion. F. HARGREAVES. *J. Iron Steel Inst.*, 171, Pt. 1, 47-48 (1952) May.

Filiform corrosion has been induced on polished steel specimens exposed to the atmosphere. Corrosion tracks, originating from slag inclusions, had developed after 24 hours' exposure; they showed brilliant interference colors. Some filiform corrosion tracks occurred on painted specimens—the longer the specimen was exposed before the coating was applied, the more numerous were the tracks.—RPI. 5722

3.6.5

The Electromotive Series for Metals and Alloys. *Metal Finishing*, 50, 89 (1952) April.

A list of the above with brief notes.—BTR. 5586

3.6.5, 6.4.2

The Potential of Aluminium in Common Salt Solution. RICHARD ERGANG, GEORGE MASING AND MARGRET MÖHLING. *Z. Elektrochem.*, 56, No. 1, 8-16 (1952) Jan.

Anode and cathode potentials of an aluminum electrode were determined at various current densities in an electrolyte of 3 percent sodium chloride. The Cl^- concentration had little influence compared to that of air. The difference between the two equilibrium points varied when the aluminum surface was polished with fine or coarse emery, etched with potassium hydroxide, rolled, or polished electrolytically. The cathodic potential drop of an electrolytically polished surface in an air-saturated solution began at about 9×10^{-3} amperes and dropped much faster than that of one polished with emery. The curve for an etched surface lay between. In an air-free solution the drop began on the anodic side. The drop was greatest for the electrolytically polished surface and least for the emery polished. The hydrogen over-voltage increased slowly with time. The potential of a polarized aluminum electrode decreased with time after the current was cut off, at a rate depending on the previous treatment of the surface. The anodic potential was almost independent of the pH; the cathodic potential rose as the pH decreased.—ALL. 5535

3.6.6, 4.6.11

On the Contact Corrosion Between Aluminum and Iron Sheet in Sea-Water. H. YAMAGUCHI AND T. SOGI. *Light Metals* (Japan), No. 4, 122-124 (1952) Aug.

Contact corrosion tests between 2S and iron sheet in sea-water under vari-



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ous conditions were carried out for 23 months. Under the following conditions, no trace of contact corrosion was noticed: 2S sheet: the entire surface, pretreated with alcohol solution containing phosphoric acid, was coated with zinc chromate primer, finished with aluminum paint, and then coated with bituminous paint at the contact area only. Iron Sheet: galvanized with zinc. In practice, better results are expected if zinc-chromate tape is used between both sheets. Paint containing compounds of copper, mercury and lead, which are injurious to aluminum sheet, should be avoided.—JSPS. 5830

3.6.6, 5.8.2

Inhibition of Galvanic Attack of Steel With Phosphate Glasses. G. B. HATCH. *Ind. and Eng. Chem.*, **44**, 1780-1786 (1952) Aug.

Glassy phosphate has been found to be a very effective inhibitor for the corrosion of steel coupled to copper and of zinc coupled to either copper or steel. The inhibition of the galvanic attack on steel coupled to copper is chiefly due to a marked increase in the cathodic polarization; the glassy phosphate film on the copper is primarily responsible for the inhibition of the galvanic attack on the steel. The effect of a number of factors, commonly encountered in practice, on the inhibition of the galvanic corrosion of steel coupled to copper with the glassy phosphate is quite similar to their effect on the inhibition of the attack of steel alone. The minor differences that exist appear to be due to the fact that the film of glassy phosphate, chiefly responsible for the inhibition of the galvanic attack, is that on the copper cathode.—NSA. 5700

3.6.6

Galvanic Corrosion. E. C. REICHARD. *Chem. Eng. Progress*, **48**, No. 6, 269-271 (1952) June. *Materials & Methods*, **36**, No. 2, 83-86 (1952) Aug.

A concise account of the main factors operating in galvanic corrosion, and the steps which have to be taken to avoid plant failures. The author stresses the importance of observing the following rules. When two metals must be used together, the anodic metal should have the larger effective area. Barrier coatings should be applied to the cathode, since breaks in an anode coating will lead to pitting failures. Insulating connections should be used to prevent the flow of electric current and inhibitors used to prevent galvanic action in recirculating liquid systems. Galvanized coatings or aluminum-clad steel should be adopted in construction whenever possible. Zinc or magnesium anodes should be fitted to pipelines or any plant where corrosion failure occurs, and this may be done as a matter of routine when the breakdown is repaired. When two metals have to be used together, the anodic one should not be the critical structural metal; but in all cases generalizations based on the laboratory galvanic series may prove misleading.—ZDA. 5739

3.6.6, 6.4.2

A Study for Preventing Contact Corrosion of Light Metals. J. KOBAYASHI AND K. SAKAGAMI. *Light Metals* (Japan), No. 4, 118-121 (1952) Aug.

Tests were carried out as follows: 52S-0 sheets of 1 mm thickness, bare or anodized, were fixed with mild steel

sheets of 1 mm thickness, in the middle of both sides, by means of bar rivets. The surface of said steel sheets was treated in different ways, namely zinc-dipping, zinc-plating, cadmium-plating, zinc-chromate coating or bituminous painting. These test pieces were left wholly immersed in a 5.85% sodium chloride and 0.3% hydrogen peroxide solution for three months. As a result, it was found that the test piece coated with bituminous paint was in the best condition. 52S sheet with anodized surface corroded more than the untreated. Needless to say, the sample coupled with bare 52S and bare mild steel was found to be most severely corroded. It seemed that in these contact corrosion tests, sodium chloride testing solution with the addition of 0.3% hydrogen peroxide had rather too severe action.—JSPS. 5641

3.6.6, 2.3.4

A Study for Preventing Contact Corrosion of Light Metals. M. MURASAWA AND M. YAMAZAKI. *Light Metals* (Japan), No. 4, 116-117 (1952) Aug.

The effect of corrosion prevention, especially on contact corrosion between light metal 52S panel and a hot rolled steel piece, which are painted and kept separated with a paste tape was examined. Testing panels holding the narrow painted steel piece at the center part, were immersed into a 5.85% sodium chloride and 0.3% hydrogen peroxide solution for a month.

52S panels were painted with zinc chromate primer, asphalt type varnish and "Vinylex" active primer (wash primer type). Steel pieces were painted with the same paint or enamelled gilsonite paste, zinc chromate paste, and polybutene paste.

According to testing results, the panel, for best corrosion-resistance, should be painted with the first coat "Vinylex" active primer, the second coat zinc chromate primer; then enamelled with zinc chromate paste. The best corrosion preventing paste was polybutene.—JSPS. 5640

3.6.6, 6.4.2

A Study for Preventing Contact Corrosion of Light Metals. M. MURATA AND I. YOSHIDA. *Light Metals* (Japan), No. 4, 113-115 (1952) Aug.

Light Metals in contact with other metals; for example, steel, corrode especially in the presence of an electrolyte, such as sodium chloride solution.

Aluminum alloy (52S) panels are wrapped with steel bands, with or without various coating or insulating pastes and submerged in an aqueous solution containing 5.85% sodium chloride and 0.3% hydrogen peroxide. In untreated (direct contact and bare) panels, aluminum panels generated gas bubbles and were considerably corroded, but the steel band was not so corroded. When a cloth tape (painted with a paste composed of polybutene, paraffin, boiled oil, gilsonite, zinc chromate, etc.) was inserted between aluminum alloy and steel, the corrosion decreased. The steel band corroded and the aluminum alloy was not affected. After immersion for over a month, no significant drop in tensile strength of the aluminum alloy was found. When the panels were coated with various coatings (zinc chromate primer, wash-primer, vinyl resin primer), they showed good resistance.

Among insulating pastes, the polybut-

tene-boiled oil-zinc chromate type paste showed the best results; among coatings, the vinyl type primer was best and the wash primer-zinc chromate primer (synthetic resin vehicle) was second.—JSPS. 5642

3.6.6, 5.8.2, 7.1

Machine Design Topics—Corrosion Inhibitor for Stored Ball Bearings. *Machine Design*, **24**, No. 9, 104 (1952) Sept.

Corrosion of in-storage ball bearings having brass retainers were found galvanic in nature according to the Naval Research Lab. Caused by the formation of small quantities of acid in both animal and mineral oils, corrosion can be reduced by inhibitors such as amine complexes of oil-soluble organic acids.—INCO. 5575

3.6.8, 3.2.3

Adsorption and the Hydrogen Overpotential. P. J. HILLSON. *Trans. Faraday Soc.*, **48**, 462-473 (1952) May.

Hydrogen overpotential and capacity of the working electrode were measured on electrodes of mercury, nickel, tungsten, tantalum, gold and silver in the presence of n-hexyl alcohol, n-caproic acid, n-hexylamine hydrochloride and p-toluene sulfonic acid. Considers differential effects of these capillary-active substances. Calculates hydrogen overpotential of various metals from literature data. Apparatus diagram, tables and graphs. 17 references.—BTR. 5511

3.6.8, 3.8.4

The Theory of Overvoltage and Mechanism of the Attack of Metals in Solution Out of Contact With Oxygen. (In French). RENE AUDUBERT. *Compt. Rend.*, **234**, 1166-1168 (1952) Mar. 10.

Theory which makes it possible to specify whether dissolution is either direct or the result of a secondary reaction. Includes calculation.—MR. 5323

3.8 Miscellaneous Principles

3.8.4, 6.3.6, 6.3.19

Electron Diffraction Studies on the Oxidation of Pure Copper and Pure Zinc Between 200° and 500°C. E. A. GULBRANSEN AND W. R. McMILLAN. *J. Electrochem. Soc.*, **99**, 393-401 (1952) Oct.

A study of crystal structures of oxide films on pure copper and pure zinc, a proposed intermediate oxide, a proposed pseudomorphic oxide of zinc, and of mechanism of low-temperature oxidation of copper. Tables. 37 references.—BTR. 5462

3.8.4, 6.3.9, 4.3.2

Solution Velocity of Molybdenum in Nitric Acid at 25°C. (In German). T. C. OWE BERG. *Z. anorg. u. allgem. Chem.*, **268**, 117-119 (1952) Aug.

The velocity of molybdenum solution in nitric acid at 25°C was experimentally determined to be $v = 186c(1-\alpha)$ mg/cm²/hr, where c is the acid concentration and α is the degree of dissociation. The velocity-determining reaction is the same as for copper in nitric acid.—NSA. 5308

3.8.4, 5.2.1, 8.9.3

Corrosion in Damp Conditions. A. J. MAURIN. *Electrotechnique*, 1951; Reprint, *J. Iron Steel Inst.*, **171**, No. 2, 212 (1952) June.

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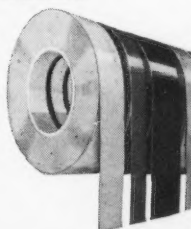
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and the use of iron-water equilibrium diagram to combat corrosion are explained. The protection of the hulls of ships by zinc strips and of gasholders and water tanks by magnesium, is shown. Some of the many special methods of protection designed for underground pipelines are described with illustrations. The theoretical calculations required for the latter are explained.—ZDA. 5732

4. CORROSIVE ENVIRONMENTS

4.2 Atmospheric

4.2.7, 7.7

Effect of Moisture and Mildew on Electronic Equipment. J. M. LEONARD. Naval Research Lab. *Elec. Mfg.*, 50, No. 3, 98-103+ (1952) Sept.

Investigation of the resistance of electronic equipment to tropical environment. The MFP treatment was undertaken as a remedial measure against moisture and mildew. Field tests at the Navy's Panama Canal Zone tropical test station were made on Navy communications receivers, of varying quality level of components, coated and uncoated. Results showed that the MFP coating did retard metallic corrosion, and there is no doubt that fungus growth was inhibited by the coating.—INCO. 5592

4.3 Chemicals, Inorganic

4.3.2, 8.4.3

Corrosion of Refinery Equipment by Sulfuric Acid and Sulfuric Acid Sludges. R. J. HAFSTEN and V. J. GROTH. Standard Oil Co., Paper before API, Div. Refining, 17th Mid-Year Mtg., San Francisco, May 13, 1952. Preprint, *Proc. Am. Petroleum Inst.*, 32M (III), 84-107, disc. 107-110 (1952).

Handling of sulfuric acid in the refinery results in many corrosion problems. Steel is used for the fabrication of tanks and vessels which contain strong sulfuric acid and strong sulfuric acid sludges. Lead is used as a liner to welded or riveted steel tanks, for resisting the corrosion of weak sulfuric acid and weak acid sludges. Strong acid and acid-sludge lines operating at moderate temperatures are fabricated of carbon-steel providing steam or other water source is not injected into the lines. Weak acid and sludges are handled by red-brass and lead lines. Tests showed that alloy 20 (Durimet 20) valves give more economical service than carbon-steel valves in strong sulfuric acid and sludge service. Weak sulfuric acid and weak acid sludges require alloy valves. Steel and brass are used for pumps. Brass is used where dilution by water or steam cannot be avoided or where weak acid and sludges are being pumped. Heating coils are made of brass or lead. Duriron has excellent erosion-corrosion resistance to sulfuric acid at all concentrations and at all temperatures up to and including boiling. Corrosion rates in sulfuric acid and acid sludges are given for Alloy 20, 33, 35, 37, Ampco 18, Pb, Cu-Ni, Durimet T, Duriron, Hastelloy B, C, D, Monel, red brass, stainless Type 309 and Worthite. Illustrations, graphs and tables.—INCO. 5567

4.3.2, 6.3.15, 6.3.20, 6.2.5

Corrosion Resistance of Titanium, Zirconium, and Stainless Steel; Mineral

Acids. LEX B. GOLDEN, I. ROY LANE, JR., AND WALTER L. ACHERMAN. *Ind. and Eng. Chem.*, 44, 1930-1935 (1952) Aug.

Corrosion rates for titanium, zirconium, and 20-29 chromium-nickel type stainless steel were determined in various concentrations of sulfuric, hydrochloric, nitric, phosphoric and mixed acids. Results in sulfuric and hydrochloric acids showed that, in general, all three materials show greater resistance to corrosion in air-free solutions than in air-saturated solutions. In sulfuric acid solutions the stainless steel is superior to titanium under all conditions, whereas zirconium excels stainless steel in all sulfuric acid solutions below 80% concentration. The three metals show excellent resistance to all concentrations of nitric acid. In mixed acid solutions both titanium and stainless steel have better corrosion resistance than zirconium. At lower temperatures the addition of small amounts of nitric acid to sulfuric inhibits corrosion of both titanium and stainless steel but increases that of zirconium. Of the three metals only zirconium is fully resistant to corrosion in hydrochloric acid solutions. Titanium is satisfactorily resistant to all concentrations of phosphoric acid only at lower temperatures. The stainless steel shows better resistance than zirconium, especially in boiling solutions. Titanium is fully resistant to an atmosphere of water-saturated chlorine, while zirconium, Type 316 stainless steel and 20-29 chromium-nickel stainless steel are badly attacked.—NSA. 5559

4.3.6, 6.3.15, 6.3.20, 6.2.5

Corrosion Resistance of Titanium, Zirconium, and Stainless Steel; Inorganic Chlorides. LEX B. GOLDEN, I. ROY LANE, JR., AND WALTER L. ACHERMAN. *Ind. and Eng. Chem.*, 44, 1935-1939 (1952) Aug.

Corrosion rates for titanium, zirconium and 20-29 chromium-nickel type stainless steel were determined in various concentrations of ferric, cupric, mercuric, stannic, nickel, manganous, sodium, ammonium, calcium, magnesium, barium, zinc and aluminum chloride solutions. With the exception of concentrated aluminum chloride solutions, titanium is fully resistant to attack by all concentrations of these metal chlorides. Tests with some lots of powder-metallurgy titanium in alkali and alkaline earth chlorides resulted in a peculiar blister type of pitting. This is ascribed to the presence of impurities in the metal, particularly magnesium chloride inclusions. Selected lots of powder-metallurgy titanium known to be essentially free of these inclusions failed to exhibit this phenomenon. Arc-melted titanium with a very low magnesium chloride content also showed no pitting. The only solution in which titanium showed excessive corrosion was 25% aluminum chloride at 100°C. Stainless steel shows poor corrosion resistance to heavy metal chlorides, except in very dilute solutions at low temperatures. This alloy is susceptible to the pitting type of attack where, although indicated corrosion rates may be quite low, the alloy must be rated unsatisfactory because of rapid penetration and perforation of the sample. Concentrated solutions of sodium, ammonium, calcium and magnesium chloride at elevated temperatures also cause varying degrees of pitting in stainless steel. Zirconium, unlike titanium, is not resistant to solutions of ferric and cupric chloride unless both

the concentration and the temperature are low. It suffers an embrittlement type of attack which, in the most severe form, causes complete disintegration of the metal to a fine powder. However, in all other chloride solutions zirconium is almost completely resistant to attack. Titanium and Hastelloy C were nearly completely resistant to attack by hypochlorite solutions, but two different types of stainless steel were badly pitted. Zirconium was highly resistant, although there was evidence of shallow embrittlement in the higher concentrations of hypochlorite, especially at elevated temperatures.—NSA. 5562

4.3.7

Peroxide Bleaching. R. L. McEWEN. Buffalo Electro-Chem. Co. *Paper Trade J.*, 135, No. 20, 244, 246-252 (1952) Nov. 14.

Preferred material of construction for concentrated bleach liquor preparation and transfer is stainless steel and/or tile, although in some cases clean iron or concrete tanks coated with silicate of soda are satisfactory. For pulp containing peroxide chemicals, contact with equipment made of alkali-proof tile, stainless steel and transite is preferred. Contamination of commercial hydrogen peroxide solution by decomposition catalysts such as copper, brass, iron, manganese and cobalt must be avoided. Graphs and diagrams and 119 references.—INCO. 5576

4.6 Water and Steam

4.6.1

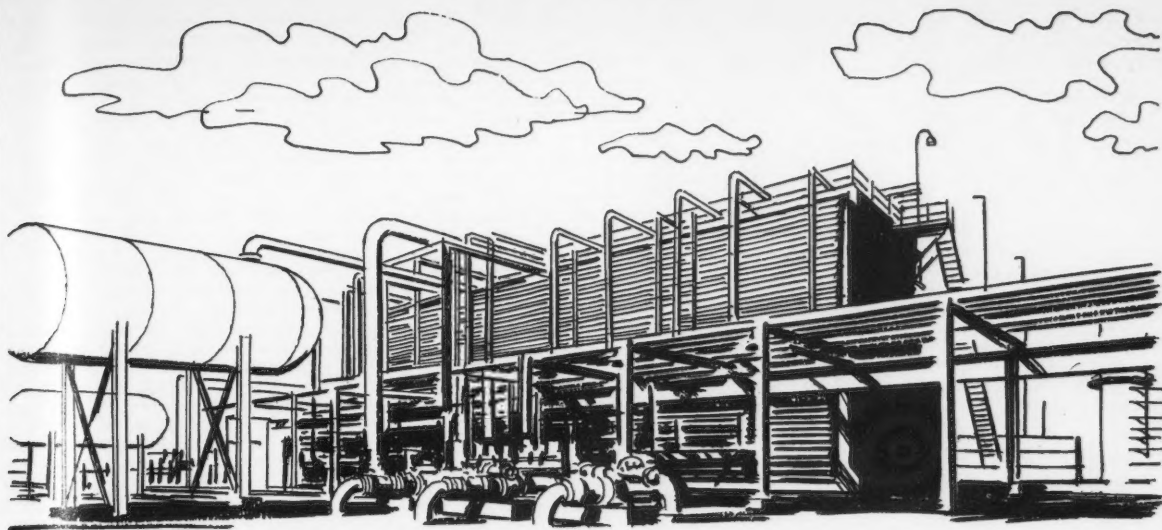
Corrosion Control in Water Systems. H. H. UHLIG. Paper No. III. Water Resources Conf., 1951. *Ind. and Eng. Chem.*, 44, 1736-1740 (1952) Aug.

Corrosion of metals used for waterworks and boiler operations will decrease as basic research in corrosion is extended. Mitigating measures are cathodic protection, metallic coatings, organic coatings, inhibitors, deaeration and use of other metals and alloys. Of the metals available having greater resistance to attack than those now used, titanium offers the most promise. 5777

4.6.2, 5.7.7, 5.8.2

Inhibitors for Eliminating Corrosion in Steam and Condensate Lines. R. C. ULMER AND J. W. WOOD. *Ind. and Eng. Chem.*, 44, 1761-1765 (1952) Aug.

Control of corrosion in steam condensate is of vital importance to the power industry. In general, two types of treatments have been advocated to control corrosion: Introduction of alkaline substances to neutralize the acidity and introduction of film-forming materials to coat the metal. Corrosion test data were obtained in 600 psi. boiler condensate with representative materials of both types. In general the type that neutralizes acidity was found to give the best results. Raising the pH to around 8.0 decreased the corrosion to an inappreciable amount in the case of iron. Use of film-forming materials also decreased the corrosion rate but not to such a low value as in the case of the neutralizing type. With both types it was found that the rate of corrosion increased at higher concentrations of dissolved oxygen. This also was true in the case of the controls. In the case of copper and brass both types have good results. In selecting a treatment for a given case, the



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metals in the system and the dissolved oxygen content of the steam should be considered.—NSA. 5793

4.6.4, 8.9.2, 5.8.2

Save That Radiator. A. S. WUKMAN. Coastal Eng. & Equipment Service. *World Oil*, 135, No. 5, 136+ (1952) Oct.

Discussion covers a recommended outline for maintaining a clean motor-cooling system. After cleaning the system, a neutralizing compound is used to compensate for excess cleaning solution adhering to the metal surfaces. The system is then charged with an inhibitor compound to treat the water against scale and rust formation. Use of a phosphate type of chemical will prevent scale formation. Chromates, forming adhering protective oxide films on metal surfaces, are highly effective in preventing corrosion.—INCO. 5812

4.6.6, 6.3.6, 7.2

Ingolins and Ingobronzes. (In German). ERNST BRUNHUBER. *Giessereipraxis*, 70, 339-340 (1952).

The increased chlorination of drinking water in Germany since 1945 has created new corrosion problems in the pipe line systems of that country. Particularly affected are valve seats and other parts that are in frequent contact with the water.

A newly developed series of copper alloys, known as 'Ingolin' alloys, contain up to 5% nickel and some manganese but no zinc. Because of the formation of a protective film, the alloys are almost completely resistant to moderately halogenated waters. Maximum corrosion resistance in this series was obtained with alloys having a melting point above 1200°C. Owing to technical difficulties in the casting process, however, copper alloys with melting points below 1200°C had to be substituted. These contain less nickel (3-4%) but small amounts of aluminum (0.3-0.4%), magnesium (0.1%), and lead (1%), and are related to a series of manganese bronzes known as MnMBz12.

'Ingobronzes,' a related series of copper alloys in which nickel is replaced by tin, are superior to the Ingolins in strength and hardness but are not suitable in contact with chlorinated water because they are readily attacked by halogens.—PDA. 5369

4.6.11, 7.7, 5.3.2

Save Stainless on Snorkels. *Welding Engr.*, 37, No. 9, 58 (1952) Sept.

Monel cladding of extensible radio and radar masts for snorkel-equipped submarines is saving the Navy money. Instead of seamless tubes of 18-8, the new design uses low-alloy steel tubing with a clad surface of Monel. The tubes must withstand salt-water corrosion.—INCO. 5805

4.6.11, 5.4.5

Protects Iron and Steel. *Steel*, 1952, 128-130, July 21.

This note on an American brand of zinc-rich paint, sold under the trade name of 'Galvanite,' refers to tests in which both bright and rusty steel were protected during two years' immersion in sea water. Both samples were free of rust at the end of this period.—ZDA. 5769

4.6.11, 6.4.2

Aluminum Alloy Dock Pilings Prove Immune to Salt Water. G. S. SCHALLER.

Univ. Wash. *Western Metals*, 10, No. 6, 53 (1952) June.

I-beams of 61S-T6 aluminum alloy were subjected to the constant action of salt water for more than two years and showed no evidence of corrosion, marine growth or barnacle build-up. The concrete part of the dock was encrusted to a 1.5-in. depth. Upon completion of the dock, all aluminum alloy sections got a brushed coat of zinc chromate paint.—INCO. 5775

4.7 Molten Metals

4.7

Corrosion by Molten Bismuth. H. A. PRAY, R. S. PEOPLES, AND W. K. BOYD. Battelle Memorial Inst., Report No. BMI-773, Oct. 15, 1952, 23 pp.

The corrosion of some 50 materials (representing low-alloy steels, transformer-grade silicon steels, stainless steels and super heat-resistant alloys) has been determined by static tests in molten bismuth at 750 and 850°C. Evaluation of the alloys was made on the basis of visual appearance, analysis of the bismuth after test and metallographic examination of the tested samples. Armco iron, SAE 1003, 1010 and chromium plate were severely attacked, while the low-chromium alloys, high-chromium irons, stainless steels and heat-resistant alloys were wet by the bismuth and moderately attacked. In general, the corrosion appeared to be the most severe at or near the liquid-vapor interface. Of the alloys tested, only the 2.9% Si transformer steels and Duriron were considered to have exhibited good corrosion resistance to molten bismuth at either 750 or 850°C.—NSA. 5670

5. PREVENTIVE MEASURES

5.2 Cathodic Protection

5.2.1, 4.6.11, 3.3.4

Cathodic Protection of Steel. F. WORMWELL, T. J. NURSE, H. C. K. ISON, AND T. W. FARRER. *Chemistry and Industry*, No. 40, 972-974 (1952) Oct. 4.

Discusses electrical current and potential requirements for the cathodic protection of steel in sea water and in the presence of sulfate-reducing bacteria. Protection of mild steel in sea water can be achieved in the early stages at a relatively noble potential provided the current density is sufficiently high, using current applied externally through a steel anode. If a 'sacrificial' zinc anode is used, however, protection can be achieved at a relatively low potential by a small current density. A more negative potential is needed in presence of the bacteria than in sterile conditions.—EL. 5806

5.2.1

Cathodic Protection. K. A. SPENCER. *Iron Steel Inst.* (London) Special Rept., 45, 75-94 (1952).

The principal causes of the corrosion of buried steel structures and the theory of cathodic protection are briefly discussed. The practical application of cathodic protection is then described, using both 'sacrificial' anodes of magnesium, aluminum, or zinc and D. C. power supply. Soil-survey methods and

the testing of cathodic-protection systems are discussed, and it is shown that the economic advantages of cathodic protection have been proved in many instances.—MA. 5766

5.2.1

Cathodic Protection of Steel in Contact with Water. LEON P. SUDRABIN AND HENRY C. MARKS. *Ind. and Eng. Chem.*, 44, 1786-1791 (1952) Aug.

The protective current requirements for the cathodic protection of steel submerged in water are controlled by the same environmental factors that influence the rate of corrosion. Higher dissolved oxygen concentrations, temperatures, or velocities that increase the rate of oxygen diffusion to the cathodic areas tend to increase the protective current requirements. Cathodically deposited calcium carbonate coatings, which impede oxygen diffusion, and resistive coatings decrease the protective current needed. Calcium carbonate is cathodically deposited most readily from water having more than 40 to 50 ppm of both calcium and bicarbonate alkalinity. In the combination of metal protective paints with cathodic protection, the best over-all results are obtained by controlling the potential at the paint surface so that corrosion activity at the coating flaws ceases and no excess current is used to damage the coatings by ampere-hour effects such as hydrogen evolution, production of alkali and electroendosmosis.—NSA. 5772

5.2.1, 8.9.3, 8.4.2

Recording Pipe Line Cathodic Protection Data. K. D. WAHLQUIST. Southern Union Gas Co. *Oil Gas J.*, 51, No. 23, 291, 293 (1952) Oct. 13.

Standardization of methods and practices of cathodic protection from corrosion of the exterior surfaces of buried pipes in a natural gas production transmission and distribution system. Practical form is described for main transmission lines, but is not so restricted. It may be used to record conditions on and along the town plant mains as well. Pertinent data including the original field survey, analysis of data, proposed locations and types of anodes and other installation details are shown.—INCO. 5829

5.2.2, 7.5.5, 8.9.3, 8.1.4

Use of Magnesium Anodes in Cathodic Protection of Tanks and Pipelines. L. E. MAGOFFIN. *J. Am. Water Works Assoc.*, 44, 407-412 (1952) May.

Experiences of California Water & Telephone Co. Although the overall cost is slightly higher than that of rectifier-type cathodic protection, ease of handling and adaptation more than offset additional cost.—BTR. 5528

5.2.2

Proper Anode Spacing Cuts Corrosion Protection Costs. *World Oil*, 135, No. 6, 262 (1952) Nov.

In practice, the most economical means of cathodic protection is to install a system of distributed small current stations. The proper spacing of the anodes is discussed, with graphs showing anode current output and hot spot current requirement for different anode spacings. 5839

5.2.2, 8.9.3

Magnesium Anodes Prove Practical for Cathodic Protection at Camp Stone-

man. P. 105-106

The S passes Stonema Much of fences, s be diffic areas of potential watered result of of five anodes intervals pipe line were less consider sonably tained areas, re sion lea ALL.

5.2.2

Magne on Its Character No. 4, 66

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5.2.2, 8.9.3

Magn yved A Jr. Pan-A No. 23, 3

Use of protection Chocolat Pan-Am be succe tion, No pipe is i after two showed mainly t tion of l sheared f inadequate future co casing pr one or a methods support i

man. P. F. OFFERMANN. *Gas*, 29, No. 9, 105-106 (1952).

The Stanpac natural gas line (7700 ft.) passes through the middle of Camp Stoneman near Pittsburg, California. Much of this line was laid under lawns, fences, streets, etc., where repairs would be difficult and expensive. Furthermore, areas of low-resistance soils, which were potentially corrosive, were found under watered flower beds and lawns. As a result of a soil-resistivity survey a group of five 17 lb. Galvo-pak magnesium anodes were installed 10 feet apart at intervals of 135 ft. and 10 ft. from the pipe line. While pipe-to-soil potentials were less than the 0.85 volt generally considered necessary for protection, reasonably good protection has been obtained throughout the more critical areas, reducing the probability of corrosion leaks to a practical minimum.—ALL. 5710

5.2.2

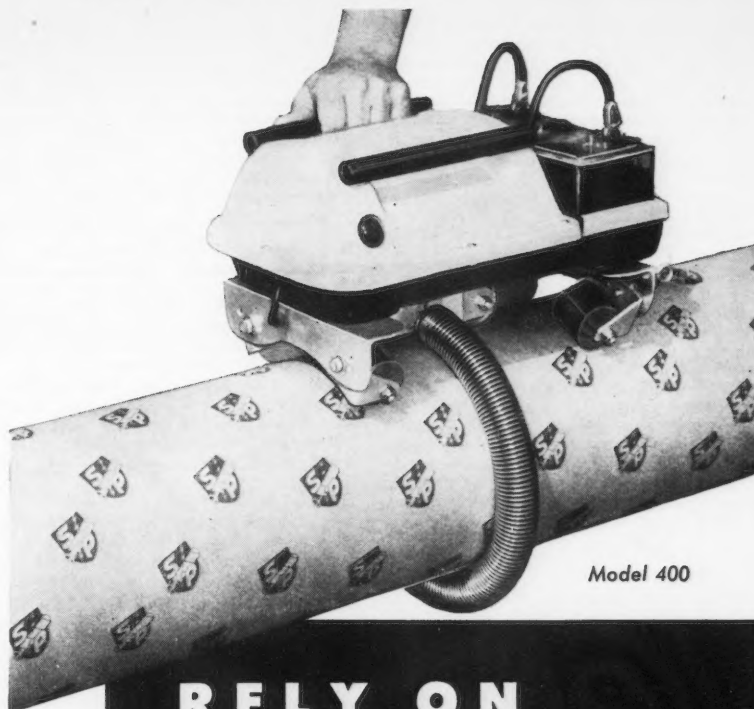
Magnesium-Ribbon Anode—Report on Its Developments and Performance Characteristics. H. A. ROBINSON. *Gas*, 28, No. 4, 60-65 (1952).

The magnesium-ribbon anode has been field tested and found to provide effective, economical protection in several different applications, including buried-pipe protection. For underground use, it offers the advantage of rapid, mechanized installation, better distribution, more efficient utilization of protective current and simplicity of installation design. Comparatively large (10 ft.) underground pipes can be protected with excellent current economy and with anode life of as long as ten years in soils of 2000 ohm-cm. resistivity and above. A purified magnesium (magnesium-1) gives higher anode efficiency and uniformity of anode consumption than the cell magnesium commonly used; further field tests are under way. The ribbon anode has been used effectively to protect a large water heater processing water of relatively low conductivity. It has the advantage of being readily shaped or arranged to give good current distribution and a high current output. In sea water and natural brines it offers a portable current source of very high output (0.5-1.0 amp. per ft.), useful in the application of lime-salt coatings required for subsequent cathodic protection. In general its use must be confined to soils and waters of intermediate to high resistivity (2000 ohms and above) if long life is desired.—ALL. 5737

5.2.2, 8.9.3

Magnesium Anode System Resurveyed After 2½ Years. C. E. SONNTAG, Jr. *Pan-American Gas Co. Oil Gas J.*, 51, No. 23, 303-304+ (1952) Oct. 13.

Use of magnesium anodes for cathodic protection on the 21-mile-long, 16-in. Chocolate Bayou transmission lines of Pan-American Gas Co. has proved to be successful after 2½ years of operation. No leaks have occurred and the pipe is in good condition. A resurvey after two years of operation, however, showed repair work was needed due mainly to insufficient depth of installation of lead wires causing them to be sheared from shallow excavation and an inadequate back-filling procedure. In future construction programs to reduce casing problems, it is recommended that one or a combination of the following methods be used: 1) Use of concentric support insulators and a type "L" rub-



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ber casing bushing; 2) a lip of "T" type gasket in conjunction with insulating guides and supports; 3) a commercial casing filler in conjunction with one of the above; or 4) insulation and coating the casing before it is pulled through into position in conjunction with methods 1) or 2). Data on anode life are given. 5767

5.2.2, 7.5.5

Cathodic Protection of Tank Bottoms. *World Oil*, 134, No. 1, 212-213 (1952) Jan.

Cathodic protection of an oil storage tank bottom may be provided at an annual cost of about 1.5% of cost of replacing the tank bottom. Assuming a —.85 volt metal-to-soil potential is needed, that a given tank bottom would require a current density of 1 milliampere per square foot of bottom surface, and a current efficiency of 500 amper-hours per pound of magnesium anode consumed, a tank of 80 feet diameter would require 17 of the type 50-R magnesium anodes for a 10-year life. 5811

5.2.3, 8.9.3

Produces Electricity From a Gas Flame. R. J. EMERSON. *World Oil*, 135, No. 5, 310, 312-313 (1952) Oct.

Electricity produced by gas-fired thermopile generators has been providing cathodic protection for two years at three remote points on El Paso Natural Gas Company's pipe-line system. 5499

5.2.3, 7.5.5.

Stop Tank Bottom Corrosion with Cathodic Protection. *Petroleum Processing*, 7, No. 5, 659-660 (1952) May.

Cathodic protection used on 12 large oil storage tanks in a refinery on the West Coast is described. The storage tanks involved were 80,000 and 100,000 bbl. capacity, all some 25 years old. Tests were conducted on one tank for experimental purposes. The third test resulted in the method adopted. 5 holes, 8 inches in diameter and 56 feet long were drilled under the tank at an angle of 30° to the ground level and starting just beyond the tank perimeter. Graphite anodes, 2 x 80 in., were placed in the holes with graphite backfill, and then backfilled with soil mixed with salt water. Current of 18 amperes was applied. After 24 hours, potential at the perimeter was 1 and at center 0.85 volts. After 2½ years the metal showed no indication of active corrosion and all the old pits were inactive. With this information, it was decided to protect the other tanks, all in one area and spaced approximately on 350 ft. centers.—INCO. 5682

5.2.3, 2.2.6

Corrosion of Buried Copper and Ferrous Strip in Natural and Salted Soils. Iron Steel Inst. (London), Special Rept. No. 45, 39-54 (1952).

A report from the British Electrical and Allied Industries Research Association. Tests were made to determine the relative corrodibility of various metals which are, or might be, used for earth electrodes, in a wide variety of soils, both natural and with addition of salt to reduce the soil resistivity. Cast iron, Armco iron, mild steel, galvanized steel, copper, and tinned copper were tested in 12 widely differing soils for periods up to 12 years. In each soil salted and unsalted sites were used; for the salting approximately 2% salt was mixed with 100 pounds of soil. The salt content rap-

idly dropped to a small fraction of its initial value. Some of the sites were re-salted after four years. Copper and tinned copper specimens were least attacked in all the soils, followed by galvanized steel. Salting increased the corrosivity of the soils, but not greatly except for certain individual soils and metals. The results obtained are compared with the results of other soil-corrosion investigations.—MA. 5709

5.3 Metallic Coatings

5.3.2, 5.4.5, 2.3.7

The Preparation of Tinplate for Painting. S. C. BRITTON. *Sheet Metal Ind.*, 29, 545-548, 558 (1952) June.

Describes experimental evaluation of various methods for the above. Results of scratch tests on painted surfaces following different pretreatments are tabulated and illustrated.—BTR. 5417

5.3.2, 5.9.4, 5.3.3, 3.8.3

Corrosion Investigations on Hard Chromium Layers. H. AREND AND F. SADRAZIL. U. S. Office of Technical Services, PB-74662, Frames 8467-8471; *Plating Notes*, 4, No. 1, 16A (1952).

The corrosion stability of hard-chrome coatings on iron and steel is due to passivation in air, causing the coated metal to behave like a noble metal. Effective chromium coatings must be dense, i.e. non-porous. The thickness required, usually 0.02-0.4 mm. depends on the corrosive medium, e.g. sea water requires a thicker coating than air. Corrosion resistance can be influenced by controlling the conditions of coating deposition to produce fine grained, continuous, homogeneous films. A very smooth surface, which can be obtained by anodically polishing the base metal increases the resistance of the chromium coating or diminishes the thickness otherwise required. Heat treatment, on the other hand, impairs the corrosion behavior, probably by widening the crazing network of the coating.—EL. 5362

5.3.2, 6.2.1, 7.4.1, 5.3.4

New Dipping Process Coats Ferrous Metals with Aluminum. *Am. Metal Market*, 59, No. 114, 9, (1952) June 13.

A dipping process by which ferrous metals may be coated economically with aluminum has been developed by General Motors Research Laboratories. The process, named "Aldip", has many potential applications including: 1. As a corrosion or rust resistant coating for ferrous metals it may in some applications replace zinc-coated metals. 2. When diffused by heat treatment it becomes a heat resistant material. This may conserve a number of strategic alloys now used in high temperature applications. 3. The method can be a continuous process for coating sheet, wire or rod stock. The process is presently being used on a pilot basis at the G-M Detroit Diesel Engine Division and at the G-M Harrison Radiator Division. At the latter plant, the "Aldip" process is being used in the production of heat exchangers. The exchangers are dipped in an alkaline cleaner, washed in hot water, run through an acid pickle, rinsed in cold and hot water, and dried in a furnace until ready for coating. They are next dipped approximately four minutes in a bath of preheating salt at temperatures ranging from 1,280 to 1,400° F. The exchangers are then trans-

ferred to an aluminum bath which is covered by a layer of salt flux about one-half inch deep where they remain for from 30 seconds to one minute. While still red hot, the exchangers are returned to the preheat salt bath and slowly raised from it.—ALL. 5297

5.3.2, 6.3.2

The Hardness of Chromate Films. A. J. W. BECK. *Metal Ind.*, 81, No. 4, 69-70 (1952) July 25.

An investigation of hardness of chromate passivated cadmium plate. The passivating solution used in the experiments consisted of sodium dichromate and sulfuric acid, as this solution was the one which gave the best corrosion resistance. The hardness of the chromate film was measured by just scratching through it to expose the plated surface. A bright cadmium gives a harder film than a dull one.—INCO. 5363

5.3.2, 2.3.2

Cadmium Plating for Salt Spray Specimens. *Metal Finishing*, 50, No. 7, 70 (1952) July.

In reply to reader's query it is suggested that 0.0002-inch of cadmium plate on steel should withstand a 24-hour salt spray test. However, if the steel is rough, a heavier deposit may be necessary. It is also important to keep the solution free from suspended matter which may cause irregularities and pin-holes in the deposit.—ZDA. 5570

5.3.2

Complex Parts Easily Coated With Aluminum. W. G. PATTON. *Iron Age*, 169, No. 24, 115-118 (1952) June.

Fabricated steel parts, even those of complicated design, can be made resistant to corrosion and heat by a new commercial process involving an aluminum-bath dip. Properties of the coating vary with the composition of the steel, duration and temperature of the dip, steel preparation, aluminum alloy composition and subsequent heating of the part. The coating comprises an iron-bearing aluminum layer on the outside and a layer of iron-aluminum alloys between it and the steel. The alloy layer, which is probably composed of a series of compounds, is brittle and this quality constitutes one of the limiting factors of the process. The iron-aluminum compound is probably formed by mutual solution of iron and aluminum rather than by aluminum diffusion into steel.

The coating process consists of first dipping the cleaned, rinsed, furnace-dried part in an immersed-electrode salt bath containing 2-2.5% sodium chloride, 8-20% cryolite, and 0.5-12% aluminum fluoride. After about four minutes, the parts are removed and immersed in an aluminum bath for 0.5-6 minutes dependent on the thickness of the coating desired. The bath is covered with a 0.5-inch layer of salt flux having the same chemical composition as the salt bath. This protects the newly coated parts on removal. Depending on the shape of the part, various methods can be used to remove excess aluminum. A suggested method is to return the part to the salt bath, raising and lowering it several times and then blowing the excess off with air.—PDA. 5648

5.3.2

Mollerizing Iron and Steel Provides Aluminum Surfaces. *Machinery* (N. Y.), 58, 179-181 (1952) Aug.

Aluminum can be united permanently with the surfaces of steel or iron parts, regardless of intricate shapes, by above process, in order to fully protect workpieces from various types of corrosion. The process consists briefly of immersing the workpieces to be treated in an electrically heated salt-bath furnace after the parts have been thoroughly cleaned and pickled. The bath has a layer of molten aluminum on top from 2-4 inches in depth. When the parts have reached the temperature of the bath, approximately 1500 degrees F, they are held for a short period, then withdrawn through the molten aluminum and consequently receive a coating of aluminum on all exposed surfaces. Illustrated.—BTR.

5655

5.3.2

Hard Chromium Plate to Improve the Corrosion Resistance of Tool Steel. H. E. RICKS. *Westinghouse Elec. Corp. Plating*, 39, No. 9, 1029-1030 (1952) Sept.

Corrosion protection offered by hard chromium plating was found to be proportional to the thickness of the chromium plate and to the surface smoothness of the tool steel panel before plating. For molds it is recommended that the surface be given a finish of 5 micro-inches or less prior to plating and that the chromium plate thickness be at least 0.0005-inch thick. Tests showed that chromium plating protects tool steel from carbonated water and from 95% relative humidity. Tables.—INCO. 5748

5.3.3, 5.3.4, 2.3.7

Recommendations Affecting Standards Relating to Electrodeposited Metallic Coatings. Paper before ASTM, 55th Ann. Mtg., N. Y., June 23-27, 1952. ASTM Report of Committee B-8 on Electrodeposited Metallic Coatings, Preprint No. 14, 1952, 4-6.

Tentative specifications for electrodeposited coatings of zinc, cadmium, nickel and chromium, and lead on steel; tentative methods of test for local thickness of electrodeposited coatings; and review of standard specifications for electrodeposited coatings of nickel and chromium on copper and copper-base alloys are discussed. Tables.—INCO. 5301

5.3.4, 3.5.1, 3.7.3, 8.8.1

Clad Steel Plate for Chemical Plant. H. CANZLER. Paper before 4th Intern. Mech. Eng. Congr., June 1952, Sweden. *Chem. & Process Eng.*, 33, No. 10, 544-546 (1952) Oct.

Description of the production of clad steel plate by hot rolling. Process consists of simultaneously subjecting plate of the basis metal and cladding metal to a high temperature without admitting air and subsequently rolling them at a definite pressure into a single plate. Basis metal used is steel of boiler steel quality. Copper, nickel, copper-nickel alloys, Monel, silver, and corrosion- and heat-resisting steels are used for cladding. Physical properties of clad plates, welding of clad plate, and chemical plate design are discussed. Cladding saves on copper, nickel, and molybdenum. Photographs, tables, and references.—INCO.

5366

5.3.4, 5.3.2, 5.9.3

Metal Spraying Technique as Applied to Protection. W. E. BALLARD. *Trans. Inst. Welding* (London), 15, 19-22 (1952) Feb.

A description of the wire process for metal spraying. The operation of the pistol is explained and the author shows, by means of diagrams, how an even coating is built up from several passes. The necessity for proper surface preparation is stressed and air and centrifugal blasting equipment described. Zinc and aluminum are the metals usually used for protective coatings and it is found that, the finer the coating structure, the better will be its performance. In practice, a compromise has to be reached between this latter consideration and the desire for rapid application.

—ZDA.

5359

5.3.4, 4.6.11

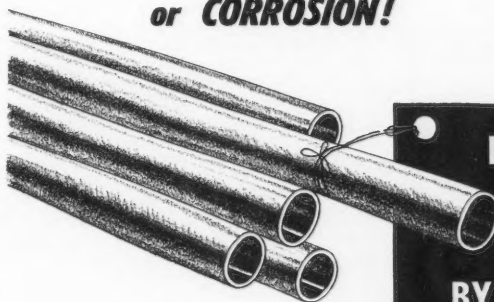
Preventing Marine Corrosion by Metallizing. H. VANDERPOOL. *Welding J.* (N. Y.), 31, 791-798 (1952) Sept.

Metallizing systems prevent rust by a combination of actions normally found singly in painting, hot-dip galvanizing and cathodic protection. A typical metallizing system consists of a clean blasted steel surface, a coat of zinc or aluminum and one or more coats of an organic film, nothing more. The surface is virgin steel and is rough. The zinc or aluminum is of very high purity and the organic film is compatible with the zinc. No flux or pickling is involved in applying the zinc and no treatment is required, such as an acid wash, to prepare the zinc for the top coatings. Zinc or aluminum is anodic to steel. Therein

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lies the major contribution of these metals as protective coatings. They hold a position above steel in the galvanic series. Coatings of bronze or stainless steel, for example, are both below steel and are cathodic to steel in sea water. Being cathodic, they accelerate corrosion of the steel if a break in the coating occurs. On the other hand, zinc or aluminum, if ruptured, sets up a cell of a reverse potential. The steel is then cathodic and cannot corrode as long as the anodic metal is in the circuit. The zinc or aluminum in a cell is a sacrificial anode providing cathodic protection when needed. This action is similar in nature to the work of a zinc slab on the stern of a ship. The slab is a sacrificial anode presenting itself as a more readily accessible anode than the zinc in the brass, preventing dezincification or pitting of brass adjacent to the stern. Sprayed metal when first sprayed presents a surface rather like No. 0 sandpaper. The surface is actually porous, a fact that is in itself not a drawback as it is not intended as a barrier coat. Because it is rough and porous it attracts initially liquid films; thus, metallizing is an ideal base for paint. Thicker coatings of paints are possible over this rough surface. It is estimated that paint life can be extended from two to five times by use of sprayed metal as a base. Likewise, the life of zinc can be extended two or three times by use of paint. In the fabrication of welded steel ships removal of slag from the weld areas has long been a problem. Slag is cathodic to steel and therefore is a source of initial corrosion, many times resulting in fracturing at or adjacent to the weld. This is commonly referred to as preferential corrosion. Standard metallizing procedures eliminate the danger of fracturing from this source. Removal of slag by the use of chipping hammers is not necessary because the metallizing preparation accomplishes this. Further, the presence of the anodic metal keeps the weld area cathodic and non-corrosive.—TIME. 5818

5.3.4, 5.9.4

Effective Pretreatment is Vital. *Product Finishing*, 5, No. 12, 51-55 (1952) Nov.

Effective paint finishing systems can only be applied to metals if the surface is in a fit condition to receive the paint. Procedures for most of the commoner metal surfaces are summarized in a table, which suggests that a freshly galvanized surface should not need degreasing before passivating. Etching primers and phosphate treatments are among the methods suggested for preparing zinc and zinc alloy surfaces for painting. Sherardized coatings do not require such pretreatments. A low temperature stoving treatment may be necessary to remove hydrogen from cadmium electrodeposits, since active hydrogen may interfere with the oxidation reactions which promote rapid drying. Chromate passivation is advocated in preparing zinc plating for painting. Sprayed zinc receives a brief mention, but no information is included about its suitability as a basis for paint without further treatment.—ZDA. 5771

5.3.4, 8.1.2, 3.7.3

The Use of Metal Spraying for the Protection of Structural Steel-Work. V. E. STANBRIDGE. *Trans. Inst. Welding* (London), 15, 23-25 (1952) Feb.; *Electroplating*, 5, No. 3, 103 (1952).

The author considers the use of metal

spraying for the anti-corrosive treatment of structural steelwork, with particular reference to the Abbey Works of the Steel Company of Wales Ltd., on which about half the steel work was metal sprayed. Methods of cleaning structural steel are indicated. The author considers a metal sprayed coat followed by a paint film the most economical treatment for steel structures, if considered over a building life of, say, fifty years. The difficulty of welding metal sprayed steel is discussed. Estimated 50-year costs for five different protective schemes, including phosphating and painting, are given.—ZDA. 5779

5.4 Non-Metallic Coatings and Paints

5.4.2, 5.4.8

Porcelain Enamels Serve and Save for Industry. W. A. BARROWS. *Barrows Porcelain Enamel Co. Iron Age*, 170, No. 20, 160-161 (1952) Nov. 13.

Porcelain enamels' resistance to acids, alkalis, water, weather, heat and thermal shock can reduce production costs substantially. By applying porcelain enamel to black steel pipe used for fluxing and degassing of aluminum, pipe life was increased by 12 to 20 times, saving more than 2 million pounds in 18 months. Additional savings resulted from lower costs of handling, cutting, threading, storage and disposal of pipe. To resist corrosion caused by molten aluminum, various refractory materials were added to high corrosion resistant coatings to increase their heat resistance. Table and photographs.—INCO. 5389

5.4.2, 6.4.2, 5.9.4

The Protective Properties of the Natural Oxide Film on Aluminum. J. M. BRYAN. Paper before Vleme Foire Internationale des Conserves et Emballage. Iere Foire de l'Alimentation, Parma, Sept. 12-25, 1951. *Chemistry and Industry*, No. 34, 820-822 (1952) Aug. 23.

Discussion of the resistance of aluminum to atmospheric and immersed corrosion due to a protective film of oxides which forms on surfaces exposed to air or liquids containing dissolved oxygen or water. These surface films can be thickened by chemical oxidation and by anodizing. A detailed study of the effect of various factors influencing the corrosion of aluminum by citric acid and citric acid-sodium chloride solutions was undertaken. Pitting and localized attack in equipment and food containers is more serious than general attack. If an aluminum product becomes contaminated with a more noble metal, local galvanic action and pitting arise. Copper and tin greatly accelerate the pitting of aluminum; nickel, manganese, lead, cobalt and iron are less detrimental but are also injurious. 6 references.—INCO. 5424

5.4.5

Zinc-Rich Paints Defined. British Iron and Steel Research Association. *Chem. Age*, 66, No. 1703, 352 (1952).

The use of the term "zinc-rich paint" should be restricted to paints containing a sufficiently high percentage of zinc pigment to ensure direct electric contact between the metallic particles in the dry paint film. There are theoretical reasons for believing that in the simplest case



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this will not occur unless the metallic zinc constitutes 92/95% by weight of the dried paint film—the exact value depending on the specific gravity and other properties of the vehicle.—RPI. 5332

5.4.5

Neoprene Protective Coatings. L. S. BAKE. E. I. DuPont. *Product Eng.*, 23, No. 8, 138-139 (1952) Aug.

A new neoprene solution, known as Type KNR cures at room temperature in 24-48 hours, and has a high solids content with low viscosity. 2 basic fields of application of neoprene coatings are—protective finishes on functional machine parts subject to corrosion and abrasion, and repairable maintenance coatings on large industrial equipment such as tanks, ducts and piping.—INCO. 5345

5.4.5

Some Newer Organic Protective Coatings. D. BUSKER. *Better Finishes & Coatings, Inc. Product Eng.*, 23, No. 8, 167-174 (1952) Aug.

Protection of metal surfaces has stimulated the development of newer coating materials. Organic coatings and films include alkyd resins, syrenated alkyds, silicone-alkyds, Teflon, Epon, acrylic resins known as Lucite and Prexiglass, urea-formaldehyde-melamine-alkyd combinations, vinyl resins and VAGH, a film former. Applications for the various coatings are given. 18 references.—INCO. 5452

5.4.5

Wax Type Protective Coatings for Industry. S. O. GREENLEE AND F. C. KRAATZ.

Paint Oil Chem. Rev., 115, 16-18+ (1952) June 5.

Chiefly discusses formulated wax systems, their properties, and uses. Briefly mentions varied applications as metal coatings including metal sparkplug shells; miscellaneous corrosion-prevention uses; impact extrusion of aluminum collapsible tubes; and deep-drawing operations.—BTR. 5458

5.4.5

Trifluorochloroethylene Polymer Resin Dispersion Films on Metal. F. E. GUSMER. A. Gusmer, Inc. *Corrosion*, 8, No. 8, 1,2 (News Section) (1952) Aug.

Trifluorochloroethylene polymer (Kel-F) dispersions are applied to selected metal surfaces by spray. No primer is required. Each coat must be completely fused before applying another. Adhesion to iron, steel, various austenitic stainless steels and aluminum has been good.—INCO. 5459

5.4.5

Chlorinated Rubber Paint for Protection and for Stopping-off. *Electroplating*, 5, No. 7, 231 (1952) July.

A short account of the chlorinated rubber paints produced by Detel Products Ltd. which give good protection against acid and alkali. They dry by evaporation and so resemble lacquers in their behavior. DMU, a zinc-rich paint giving a dry film containing over 96% of metal, is recommended for iron or steel surfaces. It has been extensively used to combat marine corrosion.—ZDA. 5464

5.4.5, 4.4.2, 6.4.2

Protection of Aluminum Surfaces. *Food*, 21, No. 247, 141 (1952).

The vessel to be protected is filled with an epoxy resin, which is poured out, leaving a film which is hardened by heat treatment. Protection against fatty acids is obtained. The use of the resins for bonding metals and plastics to rubber is noted.—RPI. 5443

5.4.5, 5.4.7

New Role for Neoprene. *Can. Chem. Processing*, 36, No. 7, 58-59 (1952) June 20.

Neoprene is now produced in a form which makes it ideal for application to the exterior of tanks, process equipment, structural steel, pipelines and vulnerable parts aboard ships and aircraft. As a maintenance coating, Neoprene has good resistance to corrosive chemicals, fumes and atmosphere; it can be prepared for application either by brush or spray gun; it dries at room temperature in 24-48 hours; it possesses a high degree of resilience, elasticity, abrasion resistance, and is non-chipping and non-cracking.—INCO. 5339

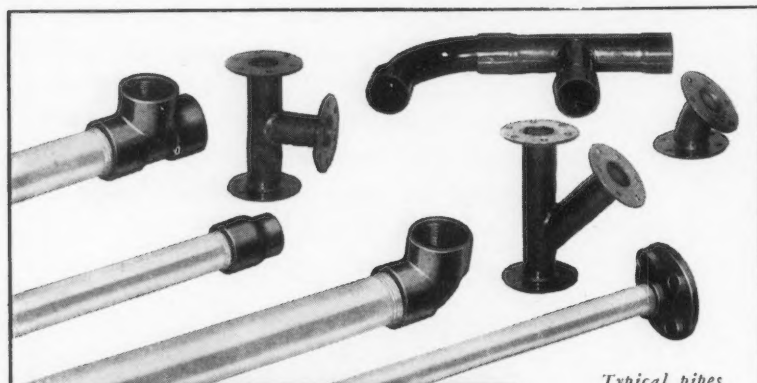
5.4.5, 5.4.8

Neoprene Protective Coatings. L. S. BLAKE. *Product Eng.*, 23, 138-139 (1952) Aug.

Neoprene rubber is now available in room temperature curing solutions with high solids content. Surveys applications in coatings. Illustrated.—BTR. 5317

5.4.5, 6.4.4

Anticorrosive Primers. A. L. ALEXANDER, H. J. E. SEGRAVE, R. FRERIKS, AND J. E. COWLING. U. S. Naval Research Lab. Paper before ACS, 121st Mtg., Mil-



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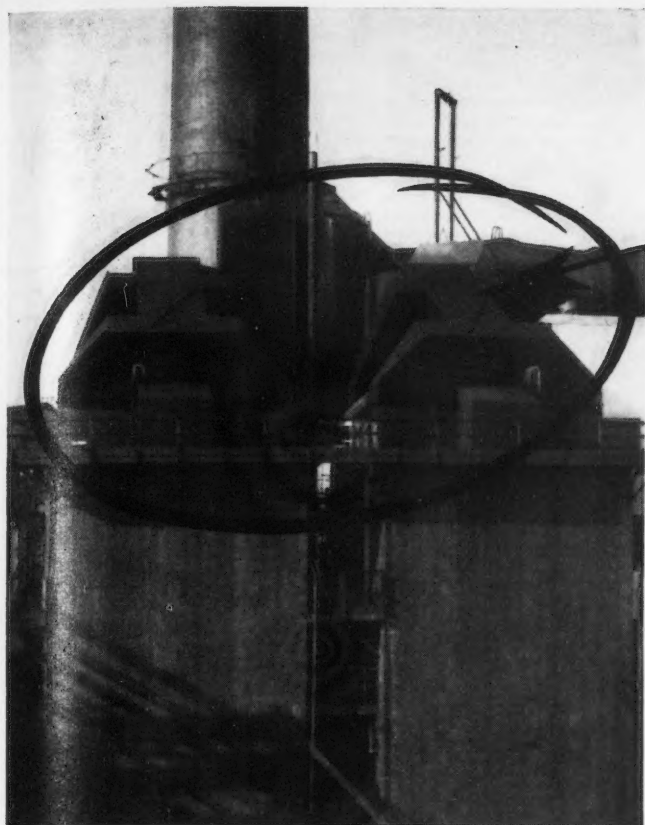
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5.9 Surface Treatment

5.9.2

The Use of Alkalis in Cleaning Processes. P. G. CLEMENTS AND T. KENNEDY. *Ind. Chemist*, **28**; Nos. 327/330; 152-157, 301-305 (1952), April, July.

First part discusses mechanism of cleaning action of alkalis (sodium hydroxide, sodium carbonate, sodium acid carbonate, silicates, phosphates), effect of hard water, etc. Second considers their effect on materials of construction (aluminum, copper, copper alloys, iron, stainless steel, tin, zinc, non-metals).—BNF. 5372

5.9.2, 5.8.1

Pickling Inhibitors. G. BATTÀ, L. SCHEPERS, AND L. GENDARME. *Chimie et Industrie*, **67**, No. 4, 577-583 (1952).

The hydrogen liberated by the pickling reaction (in sulfuric acid) was measured and the equivalent weight of iron calculated. The efficiency of the inhibitor is assessed by the ratio of the loss in iron to the total loss in weight of the steel specimen. Addition of sulfonated fatty alcohol wetting agents reduced total weight losses but did not greatly increase efficiency. The efficiency of various inhibitors was measured and is reported. Electrical methods of determining the end-point of pickling were investigated.—RPI. 5307

5.9.4

Phosphatization of Metals. J. BARY AND J. BOURGAREL. *Revetement et Protection*, No. 23, 25-33 (1952).

A general review with particular reference to the chemistry of the process, and to the different types of phosphate coating used in industry.—EIL. 5361

5.9.4, 3.2.3, 6.3.6

Oxide Films on Electrolytically Polished Copper Surfaces. J. A. ALLEN. *Trans. Faraday Soc.*, **48**, No. 3, 273-279 (1952) March.

Copper surfaces electropolished in phosphoric acid were examined for oxide by a technique of electrolytic reduction and by electron diffraction. Author concludes that the surfaces are initially free from oxide and that the subsequent growth of oxide films in air depends on the washing procedure. Surfaces freed from phosphate oxidize rapidly while those contaminated by phosphate are partially protected.—BNF. 5336

5.9.4, 6.4.4

The Protective Treatment of Magnesium Surfaces. G. P. BOLOGNESI AND G. MANTOVANI. (In Italian.) *Metallurgia Italiana*, **44**, Nos. 8/9, 336-342 (1952) Aug., Sept.

An evaluation by alternate immersion, salt spray, and atmospheric corrosion tests of 4 anodic and 10 chemical (chromate and phosphate) finishing processes.—BNF. 5314

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.1, 3.7.1, 3.5.1

Mechanical and Physical Properties of Aluminum Cast Iron. J. W. BAMPFYLDE. British Cast Iron Research Assoc. *J. Research and Development*, **4**, 340-359 (1952) June.

Reports an extensive investigation on above, one outcome of which was the development of a scale- and growth-resisting cast iron ("Cralfer"). Special treatment was developed to overcome the tendency of aluminum irons to oxidize. Details of micro-structure are given. Covers aluminum cast irons without alloy addition; and aluminum cast irons with low and with high chromium contents. Graphs, photomicrographs, and numerous tables.—BTR. 5426

6.2.1, 5.8.2, 5.4.5, 5.3.2

Protection of Ferrous Surfaces Against Corrosion. (In Italian). ERICA ANTINORI. *Tecnica ital.*, **7**, 163-167 (1952) May-June.

Presents results of further experiments similar to those described in a previous article. (Mar.-Apr., 1951 issue). Use of more concentrated solutions was studied. An emulsible oil containing sulfonic soaps gives fairly good protection from rust on cast iron. Concludes with a few practical notes on use of chromates for treatment of engine cooling water. Test-panel photographs.—BTR. 5448

6.2.4, 2.2.2

Atmospheric Corrosion of Low Alloy Steels. H. R. COPSON. *Am. Soc. Testing Materials*, Preprint No. 70, 1952, 22 pp.

In 1941 five sets of 71 low-alloy steels were exposed to the industrial atmosphere at Bayonne, N. J., and to the marine atmosphere at Block Island, R. I. Gives complete results through 9 years exposure, including weight losses, pit depths, thickness measurements, calculated pitting factors, and weight of rust on the specimens. Detailed weight-loss vs. time curves, pit-depth vs. time curves, and weight-loss vs. composition curves are plotted.—BTR. 5392

6.2.4, 3.7.3.

Endurance Limit of Welded and Unwelded Steel Specimens With and Without Influence of Corrosion. (In German). CLEMENS APPALY AND FRANZ BOLLENRATH. *Brennstoff-Wärme-Kraft*, **4**, 223-227 (1952) July.

Reports on experiments on low-alloy manganese and chromium-manganese steels, with and without exposure to aqueous corrosion. Experimental details; results tabulated and charted.—MR. 5327

6.2.5

The Cause of the Chemical Resistance of Stainless Steel. I. D. G. BERWICK AND U. R. EVANS. *J. Applied Chem. (London)*, **2**, Pt. 10, 576-587; Disc. 588-590 (1952) Oct.

Influence of anodic and cathodic treatment, corrosion rates and potentials in aerated and de-aerated acid, times of activation on replacing oxygen by inert gas, times of passivation on replacing inert gas by oxygen, and effect of con-

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nection with an external aerated cathode were studied. Experimental methods, apparatus, and results were described. Corrosion of stainless steel by dilute sulfuric acid is accelerated by anodic treatment or by cathodic treatment. In acid containing oxygen, corrosion is negligible and the potential positive; in acid freed from oxygen with hydrogen, nitrogen or argon, corrosion is rapid and the potential negative. After short exposure to oxygen-containing acid, the replacement of oxygen by another gas produces activity. The time needed for active stainless steel to become passive depends on the amount of oxygen introduced. Attack on stainless steel in 20% acid is increased by junction to carbon over which oxygen is passed. Illustrations and references.—INCO. 5335

6.2.5, 4.3.2

Corrosion (of Stainless Steels). M. G. FONTANA. *Ind. and Eng. Chem.*, **44**, No. 3, 89A-90A, 92A (1952) Mar.

Corrosion of stainless steels by sulfuric acid as a function of temperature is discussed. The three steels discussed are: 17% chromium steel, AISI Type 430; 18-8S, AISI Type 304, Alloy Casting Institute designation CF-8; and 18-8S molybdenum, Type 316, CF-8M. A note on iron blast furnace slag is also included. A graph on the corrosion of 18-8S molybdenum by sulfuric acid as a function of temperature is discussed.—INCO. 5480

6.3 Non-ferrous Metals and Alloys—Heavy

6.3.6

Properties and Corrosion-Resistance of High-Tensile Beta-Brass. A. R. BAILEY. *Metal Ind.* (London), **80**, No. 26, 519-522, 526 (1952).

Bailey outlines the history of the development of the high-tensile brasses (manganese bronzes). Seven compositions were selected, all having equivalent zinc contents based on Guillet's coefficient with aluminum varying from 0 to 4% and with addition of manganese, iron, nickel, and tin to give an estimated U.T.S. of 40 tons/in.² The alloys were subjected to tensile and corrosion tests, from the results of which it was concluded that: 1. aluminum contents greater than ~2% are undesirable, as they induce a form of latent intercrystalline brittleness which is aggravated by corrosive agencies; 2. the combined presence of iron and manganese in beta-brass containing aluminum may reduce the tendency to weakness; and 3. tensile tests in 3% sodium chloride solution may reduce susceptibility of brass to intercrystalline weakness. 12 references.—MA. 5368

6.3.6, 1.5, 1.3

Corrosion Resistance of Copper and Copper Alloys. American Brass Company, Waterbury 20, Conn. 1952, 28 pp. 8½ x 11 inches, paper cover, free.

This is a revised second edition of the findings of the American Brass Company's technical staff on the corrosion of copper and copper alloys. The contents include a discussion of the theory of corrosion and types of attack, general discussion of the corrosion resistance of copper alloys and charts in which various kinds of copper and its alloys are rated against several hundred corrosives. Anaconda alloys are tabulated

by number, alloy name, group name and indexed to a table of properties of these alloys. 5313

6.3.6, 3.2.1, 3.5.8, 3.6.6

Corrosion of Copper Alloys. E. BÖRJE BERGSMAN AND GÖTE RENMAN. Paper before Fourth Internat. Mech. Eng. Congr., Stockholm. *Metal Ind.*, **81**, No. 3, 52-53 (1952) July 18.

Paper records some examples of corrosion attack such as tarnishing and oxidation, galvanic corrosion, stress corrosion (season cracking) and dezincification. Copper and copper alloys which were unsuitably stored will be open to corrosive attack in the form of tarnishing. They can be placed in metallic contact in the presence of an electrolyte without galvanic action provided that the corrosion conditions are not too serious. Tensile stresses, cause of stress corrosion, may be eliminated by low temperature annealing or by minimizing the tensile stresses by reeling. Dezincification of brass alloys does not generally occur until after a long time of use or storage.—INCO. 5309

6.3.6, 3.2.3, 2.3.9

Gravimetric Investigation into the Oxidation of Copper-Tin Alloys at Various Temperatures. F. DE CARLI AND N. COLLARI. *Metallurgia Italiana*, **44**, No. 1, 1-5 (1952) Jan.; *Engrs. Digest*, **13**, No. 6, 183-185, 193 (1952) June.

Oxidation resistance of copper-tin alloys depends not only on the tin content of the alloy and the nature of the oxide layer, but also, on the nature of the stable phase at the temperature of oxidation. This was shown by investigations with the thermal balance method and photographic recording. Tables.—INCO. 5473

6.3.6, 3.5.8, 3.5.9

The Creep and Fatigue Properties of Two Commercial Aluminum Bronzes at 500°C. J. J. CARTER, D. N. MENDS, AND J. McKEOWN. *Metallurgia*, **45**, 273-281 (1952) June.

Concerns alloys used in tubular heat exchangers for gas-turbines. Covers: scaling behavior; creep, stress-rupture time, and fatigue tests in both cold-worked and annealed conditions; structure after these tests; effect of grain size on creep resistance of the annealed materials; and changes when held at 500-600°C. for long periods without applied stress. Structure and mechanical property data on the as-received materials are given. Graphs, tables, and photomicrographs.—BTR. 5388

6.3.9, 3.7.3, 3.5.9, 8.9.1, 7.1

Jet Engines Push Welded Molybdenum Study. W. M. BOAM. Curtiss-Wright Corporation. *Iron Age*, **170**, No. 2, 145-148 (1952) July 10.

The high melting temperature of molybdenum, 4750°F. and its thermal conductivity 7 times austenitic stainless steel, make it a prime target for study by metallurgists. Aircraft engine designers want to use molybdenum and its alloys as structure materials in gas turbine and ramjet engines. Molybdenum alloys can be fabricated by welding. Helium shielded tungsten electrodes were used in tests. If stresses are not excessive, these alloys can be used in the 3000° range. Lack of oxidation resistance is the most serious shortcoming of molybdenum. For sound welds, air and other sources of oxygen must be excluded. Weld reinforcement is needed on parts which are stretched

or formed after welding. Welds with good room temperature ductility have not been made. Photomicrographs.—INCO. 5315

6.3.11, 3.2.3, 3.7.2, 5.3.1, 5.4.1

Tarnish-Resisting Silver. *Australasian Plating and Finishing*, **1**, No. 12, 3-6 (1952).

A review of methods that have been suggested for the prevention of tarnishing of silver, such as the addition of alloying elements and coating with metallic or non-metallic films. Electrodeposition of platinum-group alloy coatings is suggested as the most likely method of protection, and the deposition of palladium from a solution containing 10 g./l. palladium as complex nitrate is mentioned.—MA. 5354

6.3.14, 3.2.3, 3.7.2

The Oxidation of Liquid Tin. (In German). WOLFGANG GRUHL AND URSULA GRUHL. *Metall*, **6**, 177-182 (1952) April.

Describes experiments on the above made on pure tin at temperatures of 325 and 600°C., and on tin with up to 1% additions of lithium, sodium, magnesium, aluminum, zinc, cadmium, antimony, lead, bismuth, and copper. The experimental results are interpreted, and show that only those metal additions which are less noble than tin, with the exception of cadmium, speed up the oxidation. In the case of aluminum, even as slight an addition as 0.5% will completely inhibit the oxidation of tin. Tables, charts, and micrographs.—BTR. 5466

6.3.14, 5.3.2

The Corrosion Resistance of Tin and Tin Alloys. S. C. BRITTON. Tin Research Institute, Apr., 1952, 77 pp.

Discussion of corrosion of tin, alloys of tin, and coatings of tin and tin alloys. Corrosion of tin includes corrosion by atmosphere, acids, alkalis, and near-neutral aqueous media. Considered in alloys of tin are pewter and britannia metal, solders and fusible alloys, bearing metals, and copper-tin alloys. Listed under coatings of tin and tin alloys are tin coatings on iron and steel-application and general properties, tin coatings on copper and its alloys, lead and aluminum, and tin-lead, tin-zinc, tin-cadmium, tin-copper, and tin-nickel alloy coatings.—INCO. 5375

6.3.15, 8.8.5, 3.7.3

Titanium Tests at High Temperatures. *Automotive Ind.*, **107**, 74+ (1952) July 1.

Results of tests on cold forming plus annealing, hot forming, scale removal, and spot welding. A basic aim was to determine the adaptability of the machines and procedures, used in forming stainless-steel components, to the forming of titanium parts.—BTR. 5299

6.3.17, 3.8.4

The Reaction Between Uranium and Oxygen. DANIEL CUBICCIOTTI. *J. Am. Chem. Soc.*, **74**, No. 4, 1079-1081 (1952).

Uranium oxidizes in accordance with the parabolic law at low temperatures and with the linear law at higher temperatures, as was found by Levesque and Cubicciotti [ibid., **73**, 2028 (1951)] to be the case with thorium; the temperature of the parabolic-linear transition is, however, lower for uranium than for thorium. A tentative explanation of the transition, based on cracking of the oxide film owing to strain, is advanced. Activation energies for the parabolic and linear uranium oxidations are calculated to be 24 and 22 kg.cal. mole, respectively.—MA. 5373

6.3.20, 2.3.6, 2.3.9, 2.5

The Corrosion of Zirconium. L. E. COLTERVAHN, W. E. RAY, AND H. J. READ. U. S. Atomic Energy Commission Publ., 1952, 14 pp.

An investigation was initiated to study the corrosion of zirconium by means of electron microscopy and electron diffraction on very thin films prepared by sputtering on a highly buffed copper foil in an atmosphere of purified krypton. Details are given of the apparatus and technique used for sputtering and for the removal of the copper from the zirconium by floating the composite film on a solution containing chrome and sulfuric acids. Preliminary exposure tests in water vapor at atmospheric pressure indicated that the temperature at which the black protective oxide changes to the white non-protective oxide is lowered by the presence of nitrogen. Attempts are to be made to vary the orientation of the zirconium film by deposition on a number of magnesium single crystals.—MA.

5413

6.3.20, 3.8.4, 3.7.4

The Corrosion of Zirconium. L. E. COLTERVAHN, W. JOSEPH, W. E. RAY AND H. J. READ. U. S. Atomic Energy Commission Publ., 1952, 19 pp.

Thin zirconium films for corrosion studies were prepared by cathodic sputtering on to electropolished copper foil. An X-ray study indicated a difference in crystal structure of zirconium oxide from that of oxide prepared from the hydroxide which had been precipitated from an aqueous solution with sodium hydroxide or ammonium hydroxide and subsequently ignited. The rate of oxidation of zirconium at temperatures up to 600°C. in air increased very rapidly in the presence of water vapor. Little success was obtained in the preparation of magnesium single crystals by the Bridgman method, which would form a basis for depositing single-crystal films of zirconium.—MA.

5374

6.3.21

The Effect of Atmospheric Gases on the Interfacial Tension Between Mercury and Several Different Liquids. F. E. BARTLETT AND R. J. BARD. Univ. of Michigan. *J. Phys. Chem.*, 56, No. 3, 532-538 (1952) April.

Measurement of mercury-liquid interfacial tensions under specially controlled conditions. It was concluded that the corrosion of mercury in contact with aerated liquids which support ionization and the resulting electrocapillary effects must be considered in the measurement of interfacial tension in unpolarized systems and that the definite, single values of interfacial tension reported for such systems provide an insufficient description of the systems upon which the measurements were made. Graphs.—INCO.

5434

6.4 Non-ferrous Metals and Alloys—Light

6.4.2, 3.7.2, 3.5.1, 3.7.3

Zinc in Aluminum Casting Alloys. DONALD L. COLWELL. *Am. Foundrymen's Soc.*, Preprint No. 52-38, 1952, 8 pp.

Data presented show that, in nominal quantities in excess of most current specifications, zinc has a beneficial effect on mechanical properties and machinability and no adverse effects on castability or corrosion resistance. Emphasis is on the common copper-silicon casting alloys,

both in the as-cast and heat-treated conditions. The danger in magnesium as an impurity is mentioned, particularly in alloy CS64C, and also the neutral effects of zinc on alloy S5C. Numerous examples are given graphically.—BTR.

5379

6.4.2, 3.7.2, 3.8.4

Aluminum-Zinc-Magnesium Alloys. (In German). P. BRENNER. *Aluminum*, 28, 216-222 (1952) July-Aug.

Discusses improvements in yield and tensile strengths of the above, also in corrosion resistance. Effects of addition of copper are described. Numerous graphs and tables show comparative properties of the various compositions. Includes effects of plating with different metals and phase diagrams for the systems aluminum-zinc-magnesium, aluminum-silicon-magnesium, and aluminum-copper-magnesium all in the aluminum-rich regions. 23 references.—BTR.

5418

6.4.2, 3.7.3, 3.5.1

High Strength Nonheat-Treated Aluminum Casting Alloys. WALTER BONSACK. American Foundrymen's Society, Preprint No. 52-44, 1952, 7 pp.

Surveys composition and properties of the above, comparing the modern aluminum-magnesium-zinc types with the older heat-treatable casting alloys. Tables and graphs give compositions, mechanical properties, and aging effects. Corrosion resistance, brazability, machinability, dimensional stability, and castability are briefly mentioned.—BTR.

5447

6.4.2, 5.3.4, 5.9.1

Electroplating of Aluminium Alloys. Aluminum Co. of America. *Aluminum Co. of America Bulletin* No. 7, May, 1952, 15 pp.

Cleaning and conditioning treatments; zincate immersion; copper strike; plating aluminum alloys; barrel plating; racking; rinsing; summary of cleaning and conditioning treatments; solutions for cleaning and conditioning aluminum alloys.—BNF.

5333

6.4.2, 8.4.3, 8.4.2

Oil Industry Continues to Use Increasing Amounts of Aluminium In Many Phases. *Am. Metal Market*, 59, No. 156, 9, 1952, Aug. 13.

The petroleum industry in the United States is using increasing amounts of aluminum in installations and equipment; the light metal replacing steel fittings. Well tubing, oil and gas lines, sucker rods and certain field structures are being designed in aluminum with a saving of two-thirds the weight of steel equipment, with no loss in strength. The excellent resistance of aluminum to sulfuric acid is being exploited in the construction of the tops and decks of sour crude oil storage tanks. Heat exchangers in the refinery itself are being made of aluminum, these exchangers comprising over 30 per cent of the total cost of the refinery. An aluminum aerial pipe line was installed in 1949 over the North Canadian fork of the Little Colorado River in Oklahoma. This span has a total length of 318 feet from pier to pier. In bridge crossings a light metal pipe line is now feasible in many cases where previously no line was possible with bridges carrying almost maximum weight as designed, where the addition of steel pipe line would bring the safety factor below its limit. Early in 1950 the

Alabama-Tennessee Natural Gas Company installed an aluminum underground gas line 1½ miles in length, for the Reynolds Metals Company. Seventeen months later the specimen section of pipe which had been laid along side the line was examined for corrosion. None was evident. A more recent examination of one of the flanges at the joint connecting the aluminum pipe to the steel line failed to reveal any damage to the pipe, although the flange had not been wrapped.—ALL.

5298

6.4.4, 8.8.5

Industrial Application of Magnesium Alloys. *Am. Metal Market*, 59, No. 97, 11 (1952) May 20.

"The Magnesium Symposium," a handbook of basic information on the industrial application of magnesium alloys has been released by the Office of Technical Services, United States Department of Commerce. The handbook is a report of a symposium held at the Army's Engineer Research and Development Laboratories in cooperation with the Magnesium Association. Included in the volume are papers on the subjects: Development and Present Status of the Magnesium Industry; Physical and Mechanical Properties and Specifications for Magnesium Alloys; Structural Design and Design for Extrusions; Design for Magnesium Castings and Forgings; Corrosion Resistance and Protective Systems; and Shop Practice—Forming, Machining and Joining. The paper on magnesium castings and forgings describes: Proper Choice of Manufacturing Process, Alloy and Heat Treatment to be Used, Dimensional Details of the Design, Fatigue, Creep and Impact. Corrosion resistance is discussed under the headings: Basic Corrosion Characteristics of Magnesium Alloys, Galvanic Couples, Surface Contamination, Protective Finishes, Cleaning and Painting.—ALL.

5331

6.6 Non-Metallic Materials

6.6.8, 4.3.1, 4.4.1

Polyethylene. *Chem. Eng.*, 59, No. 10, 260 + (1952) Oct.

Chart data presentation of the corrosion resistance of the thermoplastic material of construction, polyethylene, to a number of corrosives including organic and inorganic acids, alkalies, inorganic salts, and organic chemicals. Mechanical, physical and thermal properties, forms available and applications are given.—INCO.

5329

6.6.8, 7.6.1, 4.3.2, 4.4.2

Resin-Petroleum Coke Material Beats Corrosion. *Can. Chem. Processing*, 36, No. 12, 80 (1952) Nov.

Material for process industries is composed of —200 mesh petroleum coke and a modified phenolic resin. Wide variety of equipment is available from this material, known as Chemplas. One of the outstanding applications is hydrofluoric acid process equipment for elevated temperatures and concentrations. This material is resistant to inorganic acids and organic acids, with the exception of nitric acid above 10%.—INCO.

5355

6.7 Duplex Materials

6.7.2, 3.2.3

Oxidation Products Which Contribute to the Oxidation Resistance of Titanium Carbide-Base Cermetes. HAROLD M.

GREENHOUSE. *J. Am. Ceram. Soc.*, **35**, No. 10, 271-274 (1952) Oct.

The oxidation of titanium carbide-base cermets can be minimized if two processes are stopped: 1. diffusion of oxygen into the cermet body and 2. diffusion of cermet components through the oxide to the oxide-air interface. Two methods of curtailing these diffusion processes are considered: 1. the formation of an amorphous glassy oxide and 2. the formation of oxidation products which enable certain types of crystalline oxides to occur in a definite order. Both these methods are discussed by means of representative examples. The cermet TiC-TiB₂-CoSi represents the first method; the cermet (titanium, tantalum, niobium) carbide+cobalt represents the second method.—NSA. 5457

7. EQUIPMENT

7.1 Engines, Bearings and Turbines

7.1

Gas Turbines, Part II(b). I. G. BOWEN. *Coke and Gas*, **14**, 161-166 (1952) May.

I. G. Bowen continues discussion of fuels for the gas turbines with particular reference to solid fuels and gases. Also outlines the corrosion problems encountered and describes methods for overcoming them. Equipment diagrams and graph.—BTR. 5312

7.1.3.5.9

"Hot Copper Sandwich" May Boost Jet Performance. *Am. Machinist*, **96**, No. 12, 157 (1952) June 9.

Experiments at Ryan Aeronautical Co. are testing the high-temperature behavior of Rosslyn Metal, a clad metal, in combustion chambers and after burner vanes for jet engines. At present, combustion chambers, transition liners, and tail cones are fabricated from stainless steels, Inconel, and other chromium-nickel alloys which have high corrosion resistance but inherently poor heat conductivity. To test the advantages of Rosslyn Metal combustion chambers Ryan fabricated them from two types: 321 stainless steel clad RM and 1010 mild steel clad RM. Substituting RM for straight chromium-nickel alloys would save 30% of the scarce nickel, chromium, niobium and other metals in these alloys as the composite sheet is 30% copper.—INCO. 5433

7.2 Valves, Pipes and Meters

7.2

How to Select Valves and Fittings. *Can. Chem. Processing*, **36**, No. 9, 38, 40 (1952) Aug.

Selection of valves and fittings requires knowledge of operational conditions, such as corrosion, pressure, temperature and contamination. Valves made of cast iron, Ni-Resist, 18-8 molybdenum alloy stainless steel and Monel are used in various services depending on the corrosion resistance needed.—INCO. 5338

7.2.1.5

Curbing Corrosion in Piping Systems. *Can. Chem. Processing*, **36**, No. 5, 80, 82 (1952) May.

In addition to such factors as fluid concentration, operating temperature and pressure in pipe lines, less obvious factors

of construction details, operating conditions, possible air-in leakage, and contamination of product must be taken into account. Crane Ltd. of Montreal compiled a chart covering iron, steel, Ni-Resist cast iron, 18-8 molybdenum, Monel, nickel, red brass, acid-resisting bronze, and aluminum. Some 150 chemical solutions have been corrosion-tested with these 8 metals and alloys. Low nickel cast iron has proved much superior to nickel-free cast iron in the pulp and paper industry, and is widely used for valve bodies and fittings. Article discusses pressure and temperature, supports, dirt or foreign matter, use of strainers, and the washing or rinsing of a piping system.—INCO. 5343

7.3 Pumps, Compressors, Propellers and Impellers

7.3, 8.9.5, 5.2.1, 2.2.7

Preventing Propeller Pitting. Brit. Cast Iron Research Assoc., *Journal of Research and Development*, **4**, 392 (1952) August.

Investigations on the deterioration in service of cast iron marine propellers have been in progress (and are still continuing) since the early part of 1947, under the supervision of the Joint Propeller Panel of the British Cast Iron Research Association. A full account of this work will be published later, but the results so far achieved indicate that the severe pitting sometimes encountered in this type of attack is caused by a form of accelerated corrosion. It would be expected, therefore, that it should be possible to reduce or prevent the attack by the application of cathodic protection. A limited number of service tests on ship propellers have been carried out and very encouraging results have been obtained. There are two methods of applying cathodic protection and both are under investigation. A sacrificial anode may be used, or alternatively the protective current may be applied from a generator or storage cell coupled to an insoluble anode. Magnesium was chosen as the most suitable sacrificial anode and for various reasons it was attached to the propeller in the form of a cylindrical cone cap. A tugboat propeller was chosen for this trial. The propeller has been in use for three months and had just started to pit when the magnesium anode was fitted. Previous experience with a propeller of the same design on this tugboat had indicated that rapid pitting would have occurred during the subsequent three months' service, but in fact no further pits developed and the original pits were not enlarged. At this stage the propeller was taken out of service, for reasons other than pitting attack and a magnesium cone cap was fitted to the new replacement propeller, which would normally be expected to show pronounced attack after a period of six months. The final results of this trial are awaited with interest, but it may be noted that after four months no attack has yet developed. A possible disadvantage of the magnesium cone cap is that it is consumed as it supplies protective current to the propeller, and must be replaced from time to time. Since there is always an ample supply of electricity on board ship, it is possible that economic considerations would favor the alternative method of cathodic protection. This is being investigated on a collier fitted with a graphite anode. The current is supplied from two 12-volt storage cells, one of which is charging while the other is in use. A simple changeover switch is incorporated

into the circuit, and also an ammeter to indicate whether the propeller is receiving the necessary current. The investigators wish to extend considerably the number of field trials of these methods of protection and would welcome offers of cooperation.—E.L. 5398

7.4 Heat Exchangers

7.4.2, 3.4.6

The Problem of Corrosion in the Cooling Tubes of Transverse-Tube Coolers. (In German). WILHELM GUNTHER. *MANN. Gas-u. Wasserfach*, **93**, 169-171 (1952) April 1.

Reduced solubility of gases in the heating water may cause oxygen and carbon dioxide to accumulate along the tube walls and thus contribute to corrosion. Graphs and diagrams.—MR. 5465

7.5 Containers

7.5.2, 5.4.3

Can Linings. S. L. FLUGGE AND J. C. BRICHTA, JR. *Modern Packaging*, **25**, 131-134, 188 (1952) Aug.

Review of recent developments in protective internal coatings for steel and tinplate.—BTR. 5435

7.5.2, 6.4.2

How Aluminum Can Replace Tinplate in Containers. G. W. BIRDSALL. *Modern Metals*, **8**, No. 1, 47-48, 50-51 (1952) Feb.

Some of the activities of the Reynolds Metal Co. in this field are described, using aluminum either alone or combined with paper, plastic or fiber materials. The Reynolds can is made by winding 3S-H14 aluminum foil into layers sufficient for the structural requirements. Mention is made of a "Flex-Can" consisting of successive wraps of special foil paper, paper carton and foil paper overwrap impregnated with wax, etc.—BNF. 5325

8. INDUSTRIES

8.2 Group 2

8.2.2, 7.7, 3.6.1, 6.4.2

Better Connector Life Vital to the Use of Aluminum in Distribution. C. E. BAUGH. *Pacific Gas and Electric Co.*, San Francisco. *Elec. World*, **137**, No. 22, 82-85 (1952) June.

The unsatisfactory performance of aluminum-to-copper connectors in West-coast industrial, marine, and even rural areas discourages the adoption of aluminum conductors until a longer connector life is assured. The problem seems to be universal, location affects only the time element. The probable solution to the problem is to construct the connectors in such a manner that conducting solutions cannot bridge the two metals at points where they are in close proximity.

Serious connector deterioration can take place without any casual indication of incipient trouble. Thus, 9 out of 25 threebolt, aluminum-body, parallel-groove clamps with soldered copper liners were found defective less than 3 years after installation in the San Joaquin Valley, 100 miles inland. Bodies were cracked and broken on the copper side, apparently from decomposition and growth

of solder attacking the liners. Similar observations from other installations indicate that intimate association of aluminum with any other metal in an electrical connection will lead to trouble if a liquid electrolyte is present in the joint. Aluminum-copper connectors made on bare-stranded conductors with parallel-groove clamps, U-bolt clamps, splitbolt connectors, or any of their variations are unsatisfactory, because there is no practicable way of sealing these joints against moisture. Similarly, there is no satisfactory method for sealing outdoor connections at disconnecting switches, transformers, and circuit breakers where aluminum tubing, bus bars, or stranded wire is used. The use of noncorrosive greases or other means of preventing oxide formation is essential to the maintenance of low resistance joints. But even this presents a problem in connections on insulated aluminum cable because even highly refined vaselines tend to dissolve neoprene sheaths and adhesive surfaces of tapes.

Connections having aluminum bodies must be properly proportioned. Aluminum-aluminum connections of all types have proven fairly satisfactory in 50 years of use. Compression splices filled with an inhibited grease have a longer life than when red lead or zinc chromate is used. Grease has no adverse effect on the holding power of compression splices.—PDA. 5294

8.3 Group 3

8.3.1, 5.4.5, 5.4.2

Special Protective Finishes Essential for Farm Tractors. B. F. CAMPBELL, Harry Ferguson, Inc. *Automotive Ind.*, 107, No. 1, 34-36+ (1952) July 1.

Finishing schedules used on Ferguson tractors and implements are the result of many years of outdoor exposure and laboratory testing. The final finish coat for all equipment is gray enamel. Most of the sheet metal parts for the tractor are finished initially with one coat of a flash type primer. This primer consists of an alkyd type resin with a pigment composed of iron oxide and zinc chromate.—INCO. 5342

8.3.5, 6.3.10

Technical Facts for Food Processors on Nickel and High-Nickel Alloys. Part I. Corrosion Fundamentals and Specific Data on Tomato Units. Part II. Metal Data on Brines, Juices, Dressings, Cereals, Vegetables. *Food Eng.*, 24, 79-81+, 95-97+ (1952) Aug., Sept.

I. Describes compositions, mechanical properties, heat-transfer rates, and corrosion resistance to tomato products of the above. Data are tabulated. II. In addition to above, includes corrosion data for copper, tin, zinc, brass, bronze, soft solder, mild steel, stainless steel, and aluminum.—BTR. 5445

8.3.5, 7.5.2, 5.2.2, 5.3.2

Aluminized Cans Reduce Meat Discoloration. American Can Co. *American Can Co. Res. Bull.*, No. 22, 85-86 (1952) July.

Luncheon meat packed in plain or enameled tinplate cans occasionally became discolored (due to iron), mainly near the side seam. Cathodic protection with magnesium, zinc and aluminum was investigated; most practical means of prevention is a one-inch square of sheet aluminum welded in a center de-

pression inside the can end, but aluminum-coated or -clad steel might be better if available. Reduction of nitrite content of meat also decreases discoloration but is undesirable for bacteriological reasons.—BNF. 5302

8.4 Group 4

8.4.2, 4.4.8

Corrosion in Carbon Dioxide-Hydrogen Sulfide-Amine System. E. C. CARLSON, G. R. DAVIS, AND K. L. HUJSAK. Stanolind Oil & Gas Co. Paper before AIChE, Kansas City, May 13-16, 1951. *Chem. Eng. Progress*, 48, No. 7, 333-335; disc. 335-336 (1952) July.

Utilization of natural gas from sour gas areas has multiplied the number of plants using amine systems for gas sweetening; and in some cases, severe corrosion problems were encountered in these systems. It was found that the attack on carbon-steel tubes could be reproduced when the amine contained small residual amounts of carbon dioxide and hydrogen sulfide and the heat medium oil was 500°F. Reduction of the oil temperature to 370°F practically eliminated the corrosion. It appeared that an excessive metal temperature due to the heating medium was the principal factor in the corrosion of the tubes by stripped amine solution. Tables and diagrams are included.—INCO. 5365

8.4.3, 5.8.1

Pumping Well Service Costs Cut by Corrosion Control. BRYANT W. BRADLEY. Shell Oil Company, Tulsa, Oklahoma. *World Oil*, 135, No. 7, 214 (1952) Dec.

Corrosion inhibitors have been found to reduce drastically well service costs due to corrosion failure of rods, tubing and pumps. Well service cost trends are shown graphically for previous operation and present operation with inhibitors. About \$110,000 has been saved by Shell in the Trapp field of Kansas between 1948 and 1951 primarily through corrosion mitigation.—NALCO. 5401

8.4.3, 5.8.4, 5.7.8, 5.2.1

Drastic Cuts in Corrosion Costs in Sour Crude Field. F. H. CLEMENTS AND J. P. BARRETT. Stanolind Oil and Gas Co. *World Oil*, 135, No. 5, 264+ (1952) Oct.

Corrosion in the Midland Farms field of West Texas is being successfully attacked. Use of formaldehyde inhibitor to prevent hydrogen sulfide corrosion proved successful both from an economic and chemical standpoint. Cathodic protection on well casings to prevent microbiological corrosion is being tested. The scaling problem was alleviated by the use of common scale sequestering chemical compounds. 9 references.—INCO. 5376

8.4.3, 5.11, 5.8.4

How Corrosion Costs Cut in Sour Wells. J. A. CALDWELL. Humble Oil & Refining Co. *World Oil*, 135, No. 6, 200 (1952) Nov.

Corrosion takes place in sour wells as the result of the presence of water in the well system and is influenced by certain characteristics of the oil. From a survey made in late 1950 of 12 producing companies covering 8215 sour-crude wells, 44% were listed as being economically affected by corrosion. Conclusions drawn from the survey were: corrosion in sour-crude wells in Arkansas and

Kansas areas were more severe than in the West Texas-New Mexico area; rods, pumps and internal tubing were most severely corroded in general; and the use of corrosion inhibitors was considered to be the most efficient method of corrosion control. Substantial reduction in corrosion costs are reported as the result of the use of corrosion-inhibitors such as formaldehyde, organics and several additives and wetting agents. Remedial measures in design and operation of sour-crude wells that give promise of success in alleviating corrosion of internal casing, tubing and flow lines are summarized.—NALCO. 5455

8.5 Group 5

8.5.3, 7.6.6, 5.3.4, 6.2.3

Stainless Steel Clad Cellulose Digesters. H. CANZLER. *Chem. & Process Eng.*, 33, No. 7, 379 (1952) July.

In the sulfite pulp industry, corrosion-resisting steel containing 18% chromium, 10% nickel and 2.5% molybdenum has become the leading material for all plant items such as storage tanks, pumps, pipes, heat exchangers, and valves. With the introduction of stainless steel cladding on mild steel plate, it has also become economical to use stainless steel in the construction of cellulose digesters.—INCO. 5344

8.5.3, 7.6.6, 6.6.6, 6.2.5

Kraft Pulping. F. W. BRAINERD. Falls Paper & Power Co. *Paper Trade J.*, 135, No. 20, 203-208 (1952) Nov. 14.

Corrosion problem solved by lining the digester. Carbon brick proved satisfactory. Its use, however, does result in a serious loss in digester volume which could be avoided by the use of a thinner lining such as stainless steel. A few recent applications of the latter material are being watched by the industry with interest.—INCO. 5381

8.8 Group 8

8.8.1, 6.2.5

Canadian Stainless for Chemical Industries. J. L. COTSWORTH. *Can. Chem. Processing*, 36, No. 10, 70+ (1952) Sept.

Because of its high corrosion resistance, strength, resistance to oxidation at high temperatures, hardness and ductility, stainless steel is in great demand as equipment construction material for the process industries. The various numbers of grades and forms are mentioned.—INCO. 5408

8.8.1, 6.4.2, 1.5

Aluminum as a Construction Material for the Chemical Industry. (In German.) E. FRANKE. *Aluminium*, 28, 75-76 (1952) Mar.

Brief review, giving compositions of recommended alloys for corrosion resistance to various materials. 13 references.—MR. 5441

8.8.1, 6.6.8, 5.4.3

Plastics in Chemical Plant. G. H. BLACK. *Chemistry and Industry*, No. 30, 727-734 (1952) July 20.

A review of the applications in chemical plant construction of the plastics available in Britain, excluding natural and synthetic rubbers. The materials considered are polythene, P.V.C., perspex, nylon, P.T.F.E. and Keebush 'H', 'M'



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and 'G'. Their physical and mechanical properties are tabulated, also their suitability for use with about 100 chemicals. Any of the plastics named may be used in contact with zinc chloride or sulphate. Examples of plastic or plastic-lined plant are discussed and illustrated.—ZDA.

8.8.1, 7.6.9, 4.4.8

Swiss Solve Urea Problems. *Chem. Eng.*, 59, No. 11, 219-220, 222 (1952) Nov.

New Swiss synthetic urea process is being introduced on this side of the Atlantic. The Swiss group has developed an alloy for reactor construction which is said to be highly resistant to the corrosive conditions encountered in the process. The alloy is described only as an unusual modification of a conventional material. It does not contain lead or silver.—INCO.

8.9 Group 9

8.9.2, 5.3.2

SAE Engineers Are Cool to Copper Substitutes in Radiators. *Automotive Ind.*, 106, 42-43, 102 (1952) Apr. 1.

Discussion by a panel of experts, appraising aluminum and copper-clad steel in regard to corrosion, soldering, and other factors.—MR.

8.9.2, 6.4.2

Guide to the Use of Aluminium in Public Service Vehicles. Booklet. Aluminium Dev. Assoc. (England), April, 1952. 27 pp.

The purpose of this booklet is to provide authoritative data on the aluminum alloys suitable for use in the construction of motor vehicles for public service. Both the cast and wrought alloys are included, the latter includes specifications for sheet and plate, extrusions and other wrought forms. The most suitable practices in machining, riveting, welding and surface finishing of parts are covered as well as the precautions necessary in guarding against galvanic corrosion with other materials. Appendices list the mechanical properties of the casting and wrought alloys in various forms.—ALL.

8.9.3, 5.7.4

Dehydration on Products Pipe Line. R. P. DOUGHERTY. *Petroleum Engr.*, 28, D10+ (1952) June.

Describes natural-gas regeneration dehydrator installed by Wyco Pipe Line Co. as protection against internal corrosion. Discusses operation and operating costs. Photographs and charts.—BTR.

8.9.5, 5.2.2, 4.6.11

Magnesium Anodes Attached to Tanker "Marine Chemist." *Chem. Week*, 71, No. 19, 49 (1952) Nov. 8.

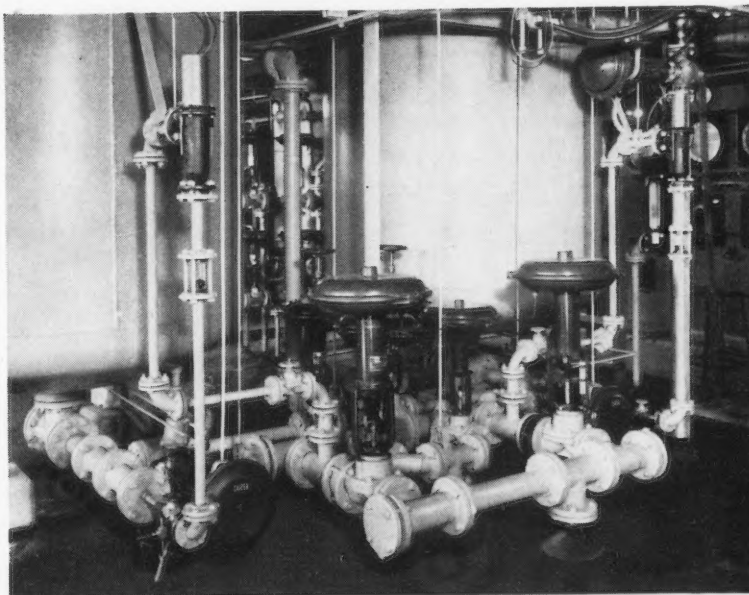
A year ago the Dow Chemical Company installed 106 magnesium castings, each weighing sixty pounds, along the line of the bilge keel on each side of their chartered chemical tanker "Marine Chemist." Periodic inspections have been made by divers. Recently the ship was put in dry dock, and the whole hull was given close inspection. This confirmed the findings of the divers that the magnesium anodes have effectively controlled underwater corrosion of the entire ship bottom.—ALL.

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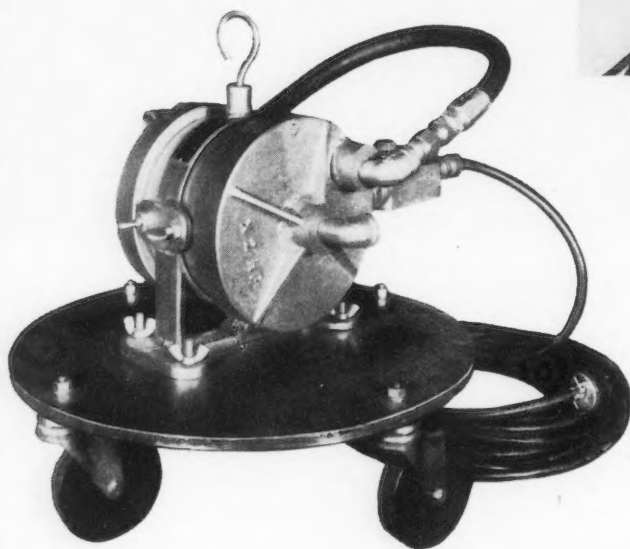
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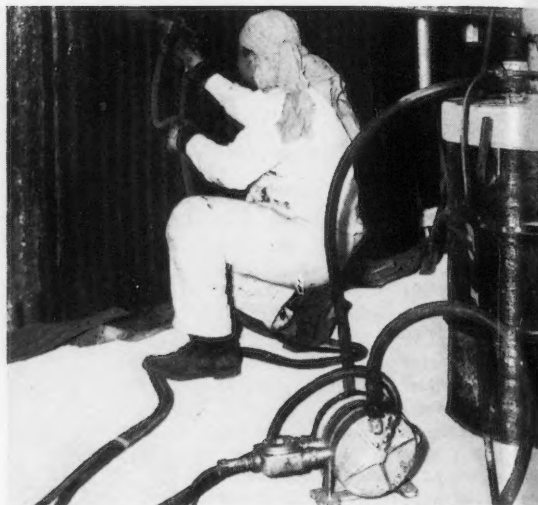
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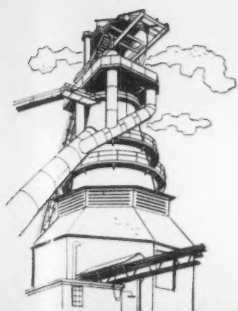
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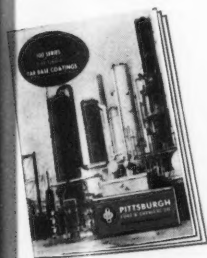


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